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**DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR INFORMATION, COMPUTER AND COMMUNICATIONS POLICY**

Working Party on Communication Infrastructures and Services Policy

BROADBAND NETWORKS AND OPEN ACCESS

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FOREWORD

The Working Party on Communication Infrastructures and Services Policy (CISP) discussed the paper in June 2012. It agreed to recommend the paper for declassification to the Committee for Information, Computer and Communications Policy (ICCP). The ICCP Committee agreed to its declassification in October 2012.

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BROADBAND NETWORKS AND OPEN ACCESS¹

Main Points

This report examines “open access” policies and approaches in various contexts, including fixed and mobile access networks, backhaul and backbone networks, undersea cables and Internet exchange points (IXPs), bearing in mind that there is no single definition of “open access” in OECD countries. Nevertheless, open access arrangements share some common elements: they refer to wholesale access to network infrastructure or services that is provided effectively on fair and reasonable terms, for which there is some degree of transparency and non-discrimination.

For fixed networks, open access policies in the form of mandated regulated access, such as local loop unbundling or other wholesale access products, have undeniably played a leading role in the development of competition, in most OECD countries, as these markets were liberalised. A variety of wholesale access products enable different levels of investment and possibilities for technological independence for new entrants. While the price level of this regulated access has often been contested, many OECD countries have achieved a far higher degree of competition than would have been the case if they had not intervened to assist in the development of market access.

Open access arrangements will also play a major role in shaping the level of competition in next generation access (NGA) networks. Some of the access remedies that were available to regulators for traditional broadband may no longer be technically or economically viable for fibre networks. As it is unclear whether there will be sufficient infrastructure competition, especially outside very densely settled urban areas, the question of how to promote competition remains at the forefront.

The scope for wholesale open access in fixed networks does not only affect products and services such as access to the local loop or wholesale service at higher levels of the network (*e.g.* bitstream). Key access products, such as dark fibre services, access to ducts or, especially, access to in-building wiring, play a major role and need to be taken into account by policy makers and regulators as they may represent a major barrier for the entry of alternative operators.

In recent years, mobile networks have also experienced, to some extent, remedies such as obligations for mobile network operators (MNOs) to host mobile virtual network operators (MVNOs) as a means to improve competition. Under some conditions, these remedies could be termed as “open access”. A number of policy makers and regulators in OECD countries fairly believe that entry of MVNOs, either through voluntary agreements with MNOs or by some type of mandated regime, has improved the level of domestic competition. Experience shows, however, that MVNOs have not been able to drive substantial

¹ The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

changes in some markets (*e.g.* international mobile roaming) where their influence is limited by a lack of access to competitive wholesale arrangements.

Open access arrangements have also been used at the backhaul and backbone network levels, for example by municipal backhaul networks, undersea cables or wholesale backbone networks. These initiatives are mostly the result of public intervention and are usually triggered by a mismatch between public policy objectives and the current outcomes of market forces.

Internet exchange points (IXPs) may be regarded as an example of open access arrangements, because an IXP typically allows its parties to exchange traffic based on agreed terms and conditions, and usually have a clear and transparent policy for members to adhere. They are usually run directly by industry participants, such as ISPs, that set their own policies and practices on a voluntary basis and under mutually beneficial terms and conditions that are open for others to join upon adherence to these rules.

Voluntary open access agreements remain relatively rare. Infrastructure sharing agreements are however fairly common, and some of these arrangements may have some degree of openness, but they are generally better categorised under the scope of purely commercial arrangements, and therefore the term “open access” may not be appropriate. The available evidence indicates that the incentive for commercial network providers to grant access to its infrastructure on open terms remains fairly low.

Many open access arrangements are a result of public funding of broadband networks. In these cases, there should be co-operation between the funding authority and the telecommunication regulator, to guarantee coherence between *ex-ante* regulation, competition law and public funding schemes for broadband networks. This would leverage the expertise of telecommunication regulators and ensure a consistent approach at all levels.

In sum, this report identifies several features that appear to be common in open access regimes in OECD countries:

- Access is provided at the wholesale level.
- Effective access is provided on fair and reasonable terms. Setting adequate price levels and avoiding non-price related discriminatory behaviours should play a major role in ensuring effectiveness.
- Access should be provided on transparent and non-discriminatory terms or, at a minimum, a clear policy should be established as to the conditions that apply to the arrangement. Transparency may also be implemented through a public reference offer.
- To date open access has rarely been provided voluntarily, and it is usually the result of direct or indirect public intervention.

Market failure has often been tackled through open access policies with relative success in a growing number of OECD countries. Moving forward, it is very likely that this will continue to be the trend and will not only be directed to fixed access networks only, but also to mobile, backhaul and backbone networks.

Introduction

The concept of “open access”, for broadband networks, or “open broadband networks”, can be referred to under a number of different scenarios, related to the establishment or treatment of these networks. These can range from commercial or voluntary arrangements, between communication operators and third-parties, through to regulatory intervention aimed at promoting certain policy objectives, such as expanding broadband availability, increasing competition, or promoting investment that may otherwise not be economic, such as in the case of enabling the establishment and treatment of shared facilities. The concept is different from “open Internet access”, which tends to refer to the use of networks by end users or the relationship between end users and these service providers. “open Internet access” addresses a higher network level than broadband open access, which is generally used to only refer to the physical, data link and network layers only.

The use of an open access policy is often highlighted as a facilitator of objectives, such as promoting greater choice for consumers or addressing infrastructure bottlenecks, especially in the context of regulated access and, in that sense is generally taken to have positive connotations by users of the term. Telecommunication networks show large economies of scale and scope that could, in some cases, impede competition in the absence of open access policies. Nevertheless, open access policies that are the result of regulation, public investment or commercial outcomes, always need to be assessed against meeting overall policy objectives. Take, for example, the use of the term when it is applied to networks with structural separation between infrastructure and services. Such a network may well increase competition at the retail level but result in a virtual monopoly at the wholesale level. At the same time, what happens if a group of, otherwise competing, network and service providers jointly invest in a network said to be an open network? Regulators face the challenge of weighing up the use of shared facilities, where such investment may otherwise be judged as uneconomic, against what this may mean for further developments in areas ranging from promoting innovation or new competitive market entry.

There is not necessarily a uniform definition of the term “open broadband access” or “open networks”, as the terms are used by different stakeholders in different contexts. The term may be applied to networks that are said to be open, for example, at different layers of networks (*e.g.* Layer 1 and 2). Nonetheless, it is widely believed that most stakeholders using these terms do refer to common features, such as transparency or non-discrimination, which involve at least a common starting point for understanding the use of the term “open access” and provides a starting point for considering what stakeholders mean by open access.

Following the liberalisation of telecommunication markets, authorities used open access as a tool to curtail bottlenecks. This was because they determined that sufficient competition would not otherwise have developed to meet their policy objectives. Across many countries, following a century of monopolies, regulators believed that some type of “open access”, in the form of regulated access to some wholesale products, such as local loop unbundling, wholesale broadband access and line-sharing, was necessary to drive competition dynamics in these markets. Regulated access has usually included certain conditions that incumbent operators must meet, such as service level agreements, delivery times and, above all, price obligations.

The level of regulated prices, together with enforcement procedures, is arguably the most significant element of any “open access” obligation imposed by regulators. Many believe the price element, among others, has played a key role in opening markets to greater competition and providing the right incentives for investment and innovation. Some have called this choice “build or buy” and they argue it provides incentives for greater investment in telecommunication networks. Others argue that under certain

assumptions, low open access prices may discourage investment in new networks both by incumbent operators and new entrants.¹ Previous OECD work has examined the role of different market structures for the deployment of next generation access (NGA) networks in different countries (OECD, 2011).

Traditional fixed broadband networks have certain technological characteristics that enable them to implement open access policies at a number of levels (at open systems interconnection's -OSI- layer 1, layer 2, and so forth). Technical constraints such as the number of interconnection points or the possibility for service differentiation clearly have an influence on the economics of broadband service provision and the resulting competition dynamics. This report will briefly summarise these factors.

The introduction of next generation access (NGA) networks is based on changes to technologies and market demand. The different technologies being used to meet these demands have significant implications on the level of new investment required and whether there will be sufficient competition. This report examines these changes and what they may mean for different open access policies. These changes may, for example, have implications for the "ladder of investment" model that has been a cornerstone of regulatory approaches since telecommunication markets were liberalised.²

Open access obligations may be imposed by public authorities based on two other legal frameworks: that of public funding of broadband infrastructures and competition law, such as in antitrust and merger reviews. A growing number of countries have certain open access conditions that operators awarded public funding (*e.g.* preferential loans, subsidies), for broadband infrastructure deployment, need to comply with if they are to be recipients of that assistance. These obligations, widely used in regional and rural areas, are aimed at assisting third-party access to infrastructure supported by public funding. The rationale is to try to ensure that public funding, of broadband infrastructure, allows the emergence of some degree of competition in a given area.³

In some countries, such as in the Netherlands, regulators and competition authorities have imposed open access obligations in the context of mergers or acquisitions. These instances, among others, provide an option for imposing open access obligations, outside the regular legal resorts available to telecommunication regulatory authorities.

While most of the attention given to open access policies has focused on fixed broadband networks, the increasing relevance of mobile communications has triggered renewed interest in "wireless open access". There is a broad range of issues in mobile markets that can be considered under the umbrella of "open access" policies. The emergence of mobile virtual network operators (MVNOs) or wholesale arrangements may well be regarded as "open access". Arrangements such as those proposed by Lightsquared, in the United States, may well fall under the scope of open access for some stakeholders.

A further area that could be considered, under this category, could be the assignment of spectrum. Some regulatory authorities have held auctions, which specify some types of open access requirements on the successful participants. In addition, the trend toward the creation of secondary markets, which may promote the shared use of spectrum, (*e.g.* time of day) may also be considered by some as having elements of an open access policy. Finally, though perhaps not exhaustively, policies that enable unlicensed spectrum, such as that used by Wi-Fi access, could be considered as a form of open access.

While technology, policy objectives and the overall market dynamics may be very different for wireless networks, some common trends may be drawn on the basis of the understanding of open access policies for wireless networks. Moreover, this report discusses "open access" arrangements at the backbone and backhaul level, for example for submarine cables, Internet exchange points (IXPs) and backbone networks and attempts to derive some conclusions on the incentives, costs and benefits of these arrangements.

Most open access experience covered by this report involves some degree of public intervention. Nevertheless, this paper also shows some examples of “open access” arrangements between market players on a voluntary basis. For example, MVNO access agreements may be achieved with little or no regulatory intervention. To the extent that they also play a critical role in the exchange of IP traffic, under a broad consideration of open access, Internet exchange points are almost wholly driven by market players, with no regulatory intervention. IXPs can be managed by non-profit, semi-public or research organisations and therefore not directly managed by infrastructure providers or they can simply be a number of ISPs who band together to form an IXP with a certain set of policies and practices. Municipal broadband networks also offer some open access connectivity, although in that case, they are usually driven by public ownership of utilities or by other public initiatives at the local level.

For the purpose of this report, open access refers to some type of effective wholesale access to broadband services, with a certain degree of “openness” – such as transparency and non-discrimination - in the access policy established for these services, either on a voluntary basis or resulting from some obligations. The degree of effectiveness in that wholesale access may be determined by several criteria, such as pricing, availability and provision and enforcement procedures.

Different scenarios and scopes for open access

It could be argued that “open access” should be addressed from a technology-neutral perspective. This report aims to do so but, given that there are economic and technological constraints with any communication network, it also focuses on different perspectives or interpretations given to “open access” in different situations depending on the underlying technology. Historically, open access policies were initially directed to fixed networks where it was assessed that these facilities could not be economically replicated or, at least, not within a time that would meet policy objectives. The same reasoning has been applied to wireless networks. First, with respect to mandated roaming, where it takes time to roll out new networks. Second, in terms of the limitations on the number of new market entrants, due to constraints in the available spectrum, some regulators opened markets to mobile virtual network operators (MVNOs).

A wide range of scenarios has emerged where “open access” principles could be applied. In addition to the “traditional” meaning of the term for fixed networks, usually concerning access networks exclusively, similar concepts have emerged in the area of next generation access (NGA) networks, wireless networks and even domestic backbone infrastructure and undersea cables. Finally, “open access” IXPs provide an example of self-regulation where the actors using these facilities establish their own rules and practices.

Open access in traditional fixed broadband networks

Based on the OSI layer model, open access in fixed networks has been traditionally addressed using the following conceptual model (see Table 1), which covers access at three possible OSI network layers, either layer one, two or three, plus access at layer 0.⁴ After the emergence of the Internet, it could be argued that a TCP/IP model could be used instead, as some access arrangements may be based on higher levels of the protocol stack (e.g. TCP/IP layer, application layer). Nevertheless, the OSI model provides a good comparison tool and is generally accepted as a good reference point by technical, economic and legal experts.

Using a relatively restrictive interpretation of the term, the following scenarios may be considered. Layer 0 access (conduits, ducts, collocation) is not a part of the network itself even though it corresponds to a significant share of the costs incurred in deploying fixed broadband networks. It may, therefore, also fall under the “open access” concept. Layer 1 comprises passive elements such as local loop unbundling or dark fibre, including the traditional copper loop and/or cable passive infrastructure. Layer 2 and 3 include

active equipment and provide for a variety of possibilities for implementation, which range from bitstream services at different levels of the network (e.g. national, regional, local interconnection at layer 2 or layer 3) or different technologies (e.g. IP-based, Ethernet-based, ATM) which allow for different technical implementations, different investment needs for alternative operators, as well as a different degree of freedom to offer differentiated services.

Table 1: Open access and OSI network layers

| LAYER | WHOLESALE SERVICE PROVIDED |
|---------------------------------------|--|
| 0 | Conduit, collocation facilities, access to ducts |
| 1 (physical layer unbundling) | Local loop unbundling, dark fibre leasing/optical layer unbundling in PONs |
| 2 (data link layer unbundling) | Layer 2 bitstream access (e.g. Ethernet, ATM), dark fibre and link-layer electronics at each end |
| 3 (network layer unbundling) | Basic network service provided, layer 3 bitstream (e.g. IP bitstream) |

Source: OECD elaboration from Lehr *et al.* (2007)

Traditionally, fixed broadband access has been provided over two main competing platforms: copper networks (DSL) and cable networks. As of June 2011, DSL and cable networks still represented 56.8% and 29.5% of the then total number of fixed wired broadband subscriptions in the OECD area (from a total of 309.4 million fixed wired broadband connections). These two technologies have different historical origins but now tend to provide very similar services: fixed voice telephony, television and/or video services and fixed broadband.

In most OECD countries, cable television networks have been upgraded from the mid-1990s onward in order to deliver bi-directional services, including broadband. Some OECD countries, such as the United States or Canada, started deploying cable television networks as early as in the 1940s. These networks have been and are being further upgraded for broadband service provision and in some cases have extensive - close to nationwide - coverage. In other countries, cable networks were developed much later and cover mainly urban areas. Unlike copper networks, open access regulation of broadband services provided over cable is relatively rare in OECD countries and, if it exists, it is implemented at a higher layer of the network. Unbundling the shared transmission channel (layer 1) is technically challenging for cable networks and is typically not mandated by regulators due to these difficulties. In addition, in many countries regulators have not considered imposing such obligations on cable operators due to their limited market share, *i.e.* it is not justified on the grounds of a dominant position held by those operators.

Wholesale broadband access over copper networks is or has been regulated to some extent in virtually every OECD country. Korea, Mexico, Chile, Israel and the United States do not mandate local loop unbundling and/or line-sharing today (in the United States copper loops are available at total element long run incremental cost prices, while line-sharing was gradually phased out during the 2000s). A more precise description of unbundling policies in these and other OECD countries will be provided below. Following telecommunications liberalisation, open access remedies such as wholesale broadband access or local loop unbundling proved necessary to introduce competition in voice telephony and broadband markets. The objective was to remove entry barriers and sunk costs that made the deployment of networks prohibitive by new entrants, especially for the local loop.

One rationale behind those obligations imposed on incumbent operators was to allow the replicability of broadband services by alternative - entrant - operators (CLEC in the United States terminology). This is illustrated by the “ladder of investment”, which represents the necessary investment by entrants to replicate broadband services and therefore provide a credible competitive threat to the incumbent (see Figure 1). The higher the rungs of the ladder, the more investment is necessary and the higher the possible technology and service differentiation. The ultimate goal of many policy makers and regulators has been to achieve full infrastructure competition, including the local loop. However, service-based competition, that is, without entrants having their complete own infrastructure and thus leasing some facilities and services from incumbent operators, has been seen as an intermediate step towards infrastructure competition. For areas that may not attract investment by multiple operators, *e.g.* scarcely populated or remote areas, service-based competition may also be an efficient long-term market structure.

Figure 1. Ladder of replicability for broadband

| |
|------------|
| Local Loop |
| DSLAMs |
| Backhaul |
| IP Network |
| Retailing |
| |

Source: Cave (2006)

As work undertaken by BEREC, entitled “BEREC report on Open Access” highlighted, there is no legal definition of the term “open access”, at least in the European Union, but regulators in European countries do have a common understanding of the term:

“The term ‘open access’ is used within Member States, although from an analysis of the responses to the questionnaire it was evident that no single definition exists. However, many countries have a similar understanding of the term in that it relates to transparent, non-discriminatory wholesale access to network infrastructure thereby enhancing competition”⁵

BEREC further noted that:

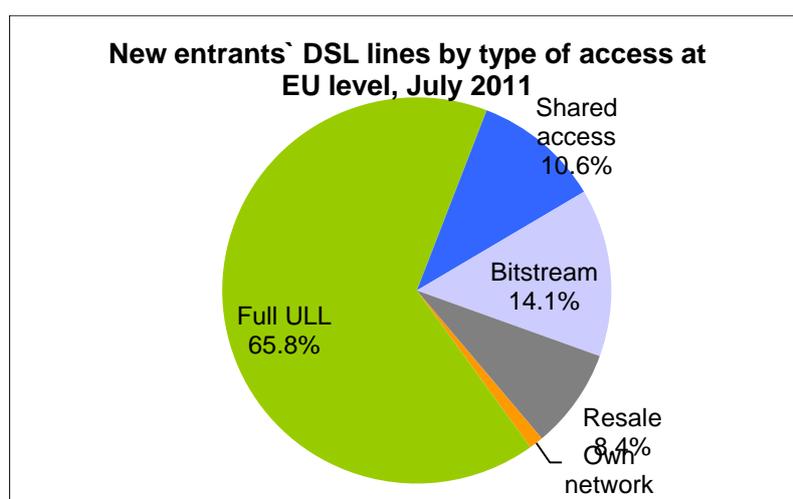
“There also was a strong view that the term should be used and understood in the context of the State Aid application process, some [Member States] suggested that it should be used exclusively in this context.”

Later, BEREC suggested replacing the term “open access” with the term “mandatory wholesale access” (BEREC, 2011a)

Local loop unbundling, however, is only one possible wholesale product that can be used by alternative DSL operators to reach the end-user premises. Other wholesale options exist, whether regulated or not, such as bitstream products, pure resale, sub-loop unbundling, unbundling at the concentration point or aggregation node, access to dark fibre or to in-building wiring and so forth.

Almost all OECD countries have used wholesale regulated access to some extent over a certain timeframe. To date, all European Union countries have made available local loop unbundling, shared access and bitstream products for alternative operators. In fact, some 75% of DSL subscriptions by entrants rely on either full local loop unbundling or on shared access (Figure 2). Alternative operators provide 46% of DSL subscription in the European Union in July 2011. The DSL market in the European Union relies heavily on the availability of wholesale products. These wholesale obligations are even more crucial in those areas where only one network infrastructure has been deployed, *e.g.* there is no cable coverage, as these areas would otherwise be confronted with a fixed network infrastructure monopoly.

Figure 2: New entrants' DSL lines by type of access at EU level, July 2011



Source: Digital Agenda Scoreboard 2011

Outside the European Union area, the situation is mixed. Some countries, such as Japan, have long had local loop unbundling obligations. Others only introduced unbundling requirements relatively recently: Switzerland (2007), New Zealand (2007). Chile only has a voluntary framework to which operators may adhere, but in practice local loop unbundling (LLU) is extremely rare in Chile.

Whether local loop unbundling and other wholesale products are available is not, of course, the only factor to be considered when assessing competition in broadband markets. Other key issues, such as the price of the copper loops and the procedure for alternative operators to request LLU provision, including service level agreements, and other such tools, can play an extremely important role in improving competition. Dysfunctional provision of LLU was among the reasons outlined in some countries that have introduced or have threatened to impose functional and/or structural separation on the incumbent operator (*e.g.* Australia, New Zealand, Sweden, United Kingdom).

Canada introduced unbundling obligations as early as 1997. However, these obligations had a five-year sunset clause commencing on 1 May 1997. The rationale behind this was to stimulate investment by new entrants to deploy their network facilities. On 11 July 2000, the CRTC initiated a public consultation on its preliminary view that the sunset clause should be extended beyond the five-year period.⁶ In 2001 the sunset period was extended indefinitely. Despite this extension, entrants have not embraced the use of unbundled local loops to compete in the provision of broadband Internet services (OECD, 2003). Some ISPs rely on resale of bitstream products provided by both incumbent telecommunication and cable operators, although such products provide little technological independence. Platform-based competition between regional cable and telecommunication incumbents accounts for much of the broadband market. In

Canada, non-incumbent ISPs only represented 7% of residential fixed broadband revenues and 31% of business fixed broadband revenues in 2011 (CRTC, 2011).

In the United States, open access policies and, specifically, local loop unbundling played a major role in telecommunication policy debates in the 1990s and 2000s. Proponents of line sharing, and extensive obligations for carriers, pointed at beneficial effects on competition, while others felt that imposing open access obligations discouraged investments and led to inefficient business models and to a suboptimal service-based competition. In the United States, the Telecommunications Act of 1996 required LLU prices be set to (total element) long run incremental costs.

Following the implementation of the Telecommunications Act of 1996, various network sharing and unbundling requirements were enforced to boost “intra-modal” competition. Several court cases significantly undermined the Federal Communications Commission’s (FCC) ability to implement the rules.⁷ Cable operators usually provided Internet access through affiliated ISPs, which were largely unregulated. In 2005, the Supreme Court upheld the FCC’s determination that cable modem services would be classified as an “information service”, and thus not subject to mandatory common carrier regulation.⁸ The FCC subsequently extended similar treatment to DSL.⁹ Since then, broadband access markets are essentially free from unbundling requirements.¹⁰ The FCC gradually eased the initial requirements through various new rules, such as those resulting from the Triennial Review Order, where it found that “excessive network unbundling requirements tend to undermine the incentives of both incumbent LECs and new entrants to invest in new facilities and deploy new technology”.¹¹

Empirical evidence on the effects of unbundling is mixed, though independent research has generally found it to be beneficial in the absence of other sources of competition. It has undoubtedly played a critical role in countries with little or no inter-modal competition and very few incumbent telecommunication operators had announced the introduction of DSL prior to regulatory authorities signalling their intention to apply unbundling policies. While the need for unbundling has been overtaken by development of effective competition in places such as Korea and Hong Kong, China, it still plays a critical role in many countries. Even then both countries, Korea and Hong Kong, China, have promoted open access to the inside wiring of apartment buildings, or other connection points for high-rise buildings, that facilitate infrastructure competition. By way of contrast, there has been little use of open access tools, such as unbundling, in some countries where there is insufficient broadband competition.

The unavailability of LLU in Mexico is partly due to the split of responsibility between several agencies in charge of declaring market players’ dominance and of imposing asymmetric regulation. This institutional setting, known as “double window”, derives in the broader inability of the regulator to impose asymmetrical obligations on the incumbent operator (OECD, 2012). By 1999, the Mexican regulator Cofetel made an attempt to impose obligations on the incumbent. After many years of litigations and injunctions filed by the fixed incumbent, these obligations have never been applied and were finally overturned in court. Starting in 2009, Cofetel is undertaking a new round of five market reviews, which could result in asymmetrical regulation imposed on the fixed and mobile incumbents. This new round is, for the time being, unlikely to address open access requirements.

Korea, Israel and Chile are the other three OECD countries where LLU is not available. It could be argued that LLU did not play a significant role in Korea being a global leader in the development of broadband services. Certainly, the demographics of the country and the early recognition of the importance of broadband by policy makers, were favourable or key factors. That being said, these factors also existed in several other countries. On the other hand, it can be noted that broadband competition started with the entry of Thrunet, which leased the cable plant from Kepco, a state-owned utility company (Kushida and Oh, 2006). The subsequent entry of Hanaro further enhanced this competition and triggered the virtuous circle of lower prices and increased penetration. While Korea now relies on facilities-based competition,

the availability of Kepco's infrastructure - a type of open access arrangement - played a crucial role in the development of competition. Today, as many countries seek to introduce greater competition there may be valuable lessons to be drawn from applying open access policies to infrastructure with public ownership or financed by utilities (*e.g.* backbone fibre associated with transport grids such as train lines) or in connection points to apartment buildings.

Another OECD country where unbundling has never been implemented is Israel. Open access - LLU and wholesale broadband access - is now being considered by the government. A public committee - "The Hayek Committee", named after its Chairman - submitted a report to the Minister of Communications recommending the adoption of a wholesale market.¹² The Ministry is now developing a set of wholesale products and tariffs for public consultation. In addition, the government is promoting the entry of the Israel Electric Company (IEC) into the market as a carriers' carrier, by setting up a subsidiary that will have access to IEC's infrastructure and will roll out an FTTH network with about 70% population coverage within seven years. The subsidiary will be majority owned by an investor who will be chosen by tender.¹³

Japan, one of the OECD frontrunners, in terms of fibre connectivity and broadband speeds, has historically relied on local loop unbundling to promote competition. The number of fibre subscribers overtook DSL subscribers in 2008. The market share of NTT West/East, the incumbent telecommunication network providers, in DSL broadband was only 35% by the close of 2009. It was as much as 74% for fibre broadband. The Japanese government is to date reluctant to remove unbundling obligations for fibre, which has existed since 2001, as they believe this would have a negative effect on competition itself. In fact, it is reducing the regulated price for the unbundled fibre loop.¹⁴ Japan is also considering functional separation to ensure that its open access policies are more effective.

Finally, Australia and New Zealand are following similar paths in changing broadband market structures. Both are structurally separating their incumbents and deploying nationwide fibre networks. Historically, New Zealand did not intervene to impose unbundling and did not enforce LLU until 2007. Since the adoption of this remedy, broadband penetration rates have significantly increased.¹⁵ LLU has also been contentious in Australia, as Telstra brought a significant number of cases to court over a long period.¹⁶ The system, largely based on arbitration by ACCC upon failed negotiations with Telstra, was not operational as many contentious issues remain, including pricing. This was undoubtedly a consideration in the Australian government's decision to deploy a national broadband network (NBN). This NBN will provide a wholesale only nationwide fibre access network aiming to reach 93% of the population. Additional wholesale facilities will be provided, to retail ISPs, through fixed wireless and satellites to service the remaining population.

Table 1. Mandatory LLU and cable open access - OECD countries

| | Mandatory LLU unbundling | Mandatory cable unbundling |
|------------------------|--------------------------|----------------------------|
| Australia | Yes | No |
| Austria | Yes | No |
| Belgium | Yes | No |
| Canada | Yes | Yes (bitstream) |
| Chile | No | No |
| Czech Republic | Yes | No |
| Denmark | Yes | Yes (bitstream) |
| Finland | Yes | No |
| France | Yes | No |
| Germany | Yes | No |
| Greece | Yes | No |
| Hungary | Yes | No |
| Iceland | Yes | No |
| Ireland | Yes | No |
| Israel | No (under review) | No |
| Italy | Yes | No |
| Japan | Yes | No |
| Korea | No | No |
| Luxembourg | Yes | No |
| Mexico | No | No |
| Netherlands | Yes | No |
| New Zealand | Yes | No |
| Norway | Yes | No |
| Poland | Yes | No |
| Portugal | Yes | No |
| Slovak Republic | Yes | No |
| Slovenia | Yes | No |
| Spain | Yes | No |
| Sweden | Yes | No |
| Switzerland | Yes | No |
| Turkey | Yes | No |
| United Kingdom | Yes | No |
| United States | Yes | No |

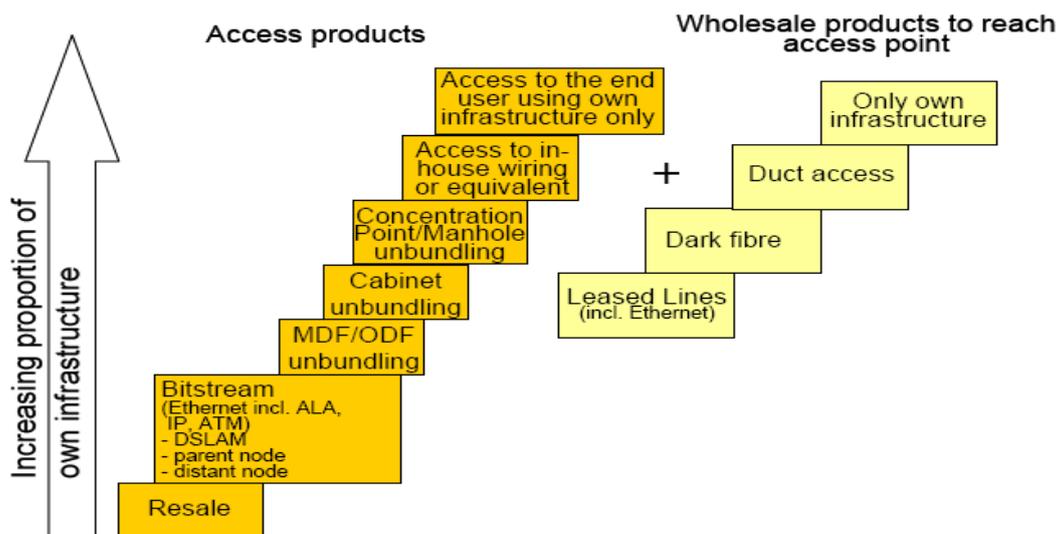
Open access in next generation access (NGA) networks

A key issue with new fibre networks is whether there will be sufficient infrastructure competition either from other fibre based networks or intermodal competition. While fibre based infrastructure competition has developed apace in some countries, such as Korea or Hong Kong, China, with open access applied only at places such as the basements of apartment buildings, it is less clear if this model can be replicated in countries with different demographics. In areas where there may only be one (virtual monopoly) or at best two (virtual duopoly) fixed network providers, the question of how to best ensure sufficient competition will be at the forefront. At the same time, to the extent that broadband wireless networks can provide a degree of this competition, they also need the use of fibre networks ever closer to their customers to efficiently offload traffic onto fixed networks. That is one reason why mobile providers have been active participants in proposals for open access networks in countries such as Italy.

As fibre networks play an increasing role in broadband service provision and fibre technology is deployed deeper in the network, moving closer to the premises (*i.e.* FTTH, FTTB, FTTC and so forth), new challenges arise as to the need and feasibility of implementing open access policies for NGA networks. These new networks have different technical and economic implications: wholesale access products are different for fibre technologies, network topologies may vary as well. In fact, new access products provide for a wide range of options available to entrants and may greatly differ from those available for copper networks. Those differences may be based, as mentioned, on technology, cost, network topology and service differentiation. In most cases, there no direct correspondence between fibre and copper wholesale access products, although some analogies may be drawn (see Figure 4).

As highlighted in previous OECD work, in an NGA environment LLU may no longer be feasible (OECD, 2010b). For point-to-point (P2P) topologies, unbundling could be feasible at the optical distribution frame (ODF), in a similar way to how unbundling was implemented in DSL networks, while for fibre, point-to-multipoint (P2MP) networks, this solution becomes more challenging.

Figure 3. NGA ladder of investment



Source: ERG (2009)

Although different unbundling options could exist for P2MP fibre networks, these might not be economically viable for entrants (e.g. subloop/splitter unbundling) or they are not yet technologically proven (WDM - wavelength division multiplexing). Therefore, it is likely that any form of wholesale access will have to be provided through indirect access obligations, as happens in cable networks. Some of these remedies may be based on “bitstream” or WDM. Nevertheless, regulators are strongly engaged with the industry in finding new, innovative wholesale products that may address some of the challenges highlighted. For example, a new bitstream access product has been required in the United Kingdom: virtual unbundled local access (VULA), which intends to provide a higher degree of independence than current bitstream products.

BEREC has discussed extensively wholesale products for NGA access and analysed the different possibilities and implications of these access products depicted above (BEREC, 2010). All the products may not be relevant in all cases, as some are specific to given roll-out scenarios (FTTH, FTTB, FTTC) and to topologies (point to point or point to multi-point: P2P and P2MP). This report does not intend to address these access products and scenarios in detail.

Unbundling at the “concentration point” - aggregation node - is relevant for some FTTH scenarios, being the concentration point located between the cabinet and the end-user or between the ODF and the cabinet. Depending on the location of the concentration point, alternative operators may be interested in unbundled access at this network level, even though some may prefer unbundled access at the cabinet or the ODF, depending on their network topology and associated economics.

Unbundling at the ODF (comparable to local loop unbundling for copper networks) may be done for P2P networks, and it does not pose any major challenges. Cabinet unbundling, whereby a lot more capital infrastructure - and therefore higher investments - is needed by the alternative operators, is mostly used for FTTC scenarios. Cabinet, concentration point and ODF unbundling are all Layer 1 products. Finally, bitstream products are possible for all topologies and fibre technologies and can be provided at Layer 2 (ATM, Ethernet) or Layer 3 (IP). As happened for cable networks, the higher the layer, the lower the technological independence for the alternative operator, which may have implications for competition in areas such as through innovation.

The deployment of NGA infrastructure has a fundamental difference with the regulation of copper: in most cases it is a newly built infrastructure and not a legacy network. Therefore, incentives for investment may play a more important role than they did for copper networks. When imposing access obligations on NGA infrastructure providers, regulators should take into consideration the balance between investment incentives and the promotion of competition. In that regard, they should consider appropriate costing methodologies, incentives that reward risk and/or uncertainty and investment recovery profiles.¹⁷

Even though this report does not attempt to address the issue of open access for NGAs in depth, it should note that some stakeholders, especially incumbent operators, argue that open access obligations would discourage investment in NGA infrastructures, whereas others, e.g. alternative operators, feel that lowering regulated prices for copper would provide an incentive for incumbents to deploy NGA networks.

In-building wiring regulations

Local loop unbundling and bitstream are key wholesale access products, but alternative operators typically need additional products or services in order to build their networks: collocation, access to ducts, dark fibre services and so forth. Specifically, some countries have identified the access to in-building wiring infrastructure as a key potential barrier preventing the deployment of broadband networks, especially NGA networks. These countries have developed regulations or best practice guidelines aimed at overcoming what may otherwise be a bottleneck to infrastructure competition.

While it could be argued that some of these initiatives have been put in place on the basis of national legislation, some regulatory frameworks for telecommunications already allow for such measures to be taken. Indeed, provisions concerning in-building wiring are usually targeted at all operators or, at a minimum, at those interested in deploying their networks in a given building. This is the reason why they are mostly imposed on a symmetrical basis, without having to declare market power exerted by one provider in the marketplace. For example, the European Union “Telecoms Package” reinforces the ability of regulators to impose the sharing of in-house wiring:

“...national regulatory authorities shall, taking full account of the principle of proportionality, be able to impose the sharing of such facilities or property, including buildings, entries to buildings, building wiring, masts, antennae, towers and other supporting constructions, ducts, conduits, manholes, cabinets.”¹⁸

Accordingly, regulators should consider promoting in-building infrastructure (and cost) sharing, namely to the fibre cabling towards individual apartments, and avoid exclusivity agreements. In this context, some European Union countries have imposed symmetrical obligations for the party deploying in-house wiring based on national law, namely Spain, Portugal and France (BEREC, 2011b). In Finland all in-house wiring belongs to the house owners and is therefore not included in the wholesale market definition. Such an arrangement also takes place in Sweden and Korea (Box 1) where, in addition, a very effective framework has been developed for labelling new buildings depending on their fibre connectivity. This framework has played a major role in transitioning to “fibre-ready” multi-dwelling buildings.

Box 1. In-building wiring in Korea

Korea is one of the leaders in the deployment and take-up of fibre optic networks in the OECD area. The percentage of fibre connections in total broadband subscriptions reached 57% in June 2011, close to Japan with 61%. This successful penetration of fibre networks is however underpinned by a decade-long effort to enhance the in-building wiring framework for multi-dwelling buildings in Korea, which was perceived as one of the main ways to facilitate greater competition in fibre infrastructure deployment.

The Building Certification Programme (BCP) certifies that an apartment building complex is equipped with suitable communication infrastructure for fibre-based broadband services. For instance, when every apartment building is connected to at least four optical cables (*i.e.* in-building facilities such as main telecommunication rooms, ducts, and wiring for FTTH services for residents), it qualifies for BCP’s “supreme grade”. BCP has two other grades, first and second, both of which should ensure FTTB connectivity. Unshielded twisted pair (UTP) cables are used for in-building wiring for first- and second-grade buildings and apartments. The programme can be applied to most of the apartments and major buildings in the country. If a building is compliant, the applicant is awarded a certificate and given permission to publish and advertise the award.

Korea’s Building Certification Programme’s certificates



Introduced in July 1999, BCP is now the *de facto* standard for in-building wiring, especially in multi-dwelling residential units. 28.8% of Korean households comply with BCP (13.2% with “supreme grade”, 60.9% with “first grade”, and 25.9% with the “second grade”). The most striking feature of BCP is that it is not based on the regulation of in-house wiring but on competition in the housing market. Current regulations for in-building wiring in Korea do not require facilities for FTTH nor FTTB. The Korean government, assisted by a growing housing market, succeeded in upgrading in-building wiring in most new apartments to the “superior” fibre-based system. Bearing in mind that 58.6% of Koreans live in apartment buildings, it can be noted that this programme has significantly increased competitive access to in-house facilities and prevented apartments being locked into a single provider, without much greater cost for residents to change operators.

Source: Information provided by the Korean government

Structural/functional separation and open access

Another option for regulators, having not achieved policy objectives using other remedies, is to implement structural or functional separation. In these cases the wholesale, or the tasks undertaken by the network provision branch of the incumbent operator, is separated in a way that non-discriminatory access is provided to its own retail division as well as to competing alternative retail operators. This has often been called “equivalence of input/EOI”. This form of access - once the network/wholesale component has been separated - is often referred to as “open access”, and it shares some of its widely accepted features (e.g. non-discrimination, transparency).

Australia’s NBN is arguably the most ambitious broadband funding project undertaken by a government since the telecommunications industry’s liberalisation. The project was designed in response to strong concerns about competition dynamics in the Australian telecommunication market, particularly lack of private sector investment in next generation broadband. While the NBN’s access arrangements are based on the telecommunications access regime that is already in place, there are significant enhancements to it. The NBN legislation requires that services offered over the network must be provided on a wholesale-only basis, that is, there is no conflict of interest in NBN Co., the company operating the NBN, competing against its customers in downstream retail markets. Services are supplied on an open access and non-discriminatory basis with oversight from the Australian Competition and Consumer Commission (ACCC). NBN Co. must publish all its service offers.¹⁹ The ACCC must be notified of any agreements that differ from the published offer. The only exception to the open access principle is when NBN Co. has reasonable grounds to believe that the other person would fail, to a material extent, to comply with the terms and conditions on which the service is supplied, for example, when there was evidence that the customer was not creditworthy or had repeatedly failed to comply with NBN Co.’s terms and conditions. NBN Co. is also subject to ACCC powers to make access determinations and binding rules. In November 2011, NBN Co. published its “Wholesale Broadband Agreement as its Standard Form of Access Agreement”.²⁰

The NBN Co Fibre Access Service is an Ethernet-based, layer 2 virtual connection on the NBN Co Fibre network that carries traffic between a User Network Interface (UNI), located at or near the premises, and the Network-to-network Interface (NNI) at the Point of Interconnect (POI) associated with the serving area in which those premises are located.

Australia’s NBN open access arrangement shares most of the characteristics of a regulated, wholesale access FTTP network, including transparency, non-discrimination, a public reference offer, and so forth. Even though the motivation and history of the NBN makes the Australian case very specific, being a wholesale-only, publicly funded network, it can be regarded as a regulated open access scheme.

One factor, however, that may differentiate some open access networks is the extent to which they have a monopoly, or virtual monopoly, over the provision of wholesale infrastructure. It is not uncommon for some city-based “open access” networks to have a monopoly or virtual monopoly (e.g. Stokab, Stockholm’s city-owned network of dark fibre). By way of contrast, some open access networks are subject to entry by other providers (e.g. commercial wholesale networks for undersea cables to local access). Monopoly power can arise from legal restrictions (e.g. limitations on access to or construction of ducts or poles) or simply because a virtual monopoly exists due to public funding making it uneconomic for competing private investment.

In New Zealand, a publicly-funded national broadband network is also being deployed by Crown Fibre Holdings. Regarding open access requirements, the arrangement is very similar to that of NBN Co., as Crown Fibre Holdings has also published a wholesale reference offer, and retail providers will serve final customers and businesses.²¹ The reference offers contains bitstream layer 2 services, dark fibre rental and commercial backhaul services.

New Zealand's approach, however, has a number of differences. The government initially granted a ten-year forbearance from regulation to the successful bidders for the public-private partnership, which triggered concerns on the part of alternative operators and consumer associations.²² In May 2011, the Minister announced that contractual arrangements would apply if the prices Crown Fibre Holdings establishes for its products were above prices regulated by the Commerce Commission.²³

Australia's and New Zealand's approaches are therefore, to some extent, unique. While Australia's NBN fully falls into the system of ex-ante regulation, managed by the ACCC, in New Zealand this is less clear and this issue has been subject to public scrutiny and to a high degree of controversy.

Finally, it can be noted that some other countries have experienced measures aimed at functional separation of the incumbent telecommunication operators (*e.g.* Sweden, the United Kingdom) with the changes in Sweden being introduced prior to legislation and those in the United Kingdom following changes to that country's approach. In those cases, the incumbent operator remains fully subject to regulatory obligations such as the wholesale reference offer or price regulation. The aim of the measures towards functional separation, a fairly intrusive remedy, has been to enforce regulatory obligations effectively, achieve the EoI principle and overcome resistance from incumbents to accept *ex-ante* regulation. Under European Union law, it is a "last resort" remedy that is only applicable if other remedies have failed to achieve effective competition, and there is no or little prospect of infrastructure competition within a reasonable timeframe.²⁴

While regulators have used functional separation for a number of years in relation to broadband networks, the use of structural separation for NGA networks is relatively recent. Outside the OECD area Singapore has adopted a structurally separated model for their national broadband network. Its regional neighbours Australia and New Zealand have also introduced structural separation for NGA deployments. While there are other examples of wholesale broadband networks resulting from commercial or government action (*e.g.* city based networks) the examples of Australia and New Zealand are most cited in OECD countries.

Regulated wholesale access for structurally and functionally separated networks shares some of the concerns and/or challenges of the regulation of a vertically incumbent operator but, theoretically, it should be easier to implement as some of the concerns regarding incentives to discriminate against third-party providers no longer exist. In any case, telecommunication regulators need have the resources and mandate to undertake this work especially if "open access" approaches result in monopoly power at the wholesale level.

Open access and public funding of broadband networks

A further distinction could be made when open access is provided to an infrastructure that has benefitted from some degree of public funding. In fact, "open access principles" usually appear in connection with some type of public funding of broadband networks. In the European Union, "open access" is used when referring to public funding frameworks (state-aid, see Box 2). Moreover, local and municipal broadband networks funded by public authorities in the United States and in the European Union usually adopt this concept, with slight variations, to highlight that wholesale access to broadband networks or services will be provided.

Box 2 Public funding of broadband networks in the European Union: the state-aid rules

According to BEREC, based on a questionnaire submitted to Member States, there is no legal definition for “open access” in the European Union. A possible exception is the public funding context (*Community Guidelines for the application of State aid rules in relation to rapid deployment of broadband networks*) –or ‘state aid’- where it is somewhat defined:

“Accordingly, the recognition of an SGEI mission for broadband deployment should be based on the provision of a passive, neutral and open access infrastructure. Such a network should provide access seekers with all possible forms of network access and allow effective competition at the retail level, ensuring the provision of competitive and affordable service to end users.”

“For example, an ADSL network should provide bitstream and full unbundling, whereas a NGA fibre-based network should provide at least access to dark fibre, bitstream, and if a FTTC network is being deployed, access to sub loop unbundling”.

Therefore, in the sense of the Guidelines, open access refers to mandated, transparent, non-discriminatory and effective wholesale access to broadband network(s) as a condition for being awarded subsidies. The term “open access” is used as a synonym of “effective wholesale access” and covers both passive and active access. The Guidelines also establish different conditions, depending on the type of subsidy granted, namely:

- Absence of state-aid:
 - Market Economy Investor Principle (MEIP): capital injection or equity participation on market terms (i.e. no “state aid” obligation applies).
 - Public service compensation in the form of Service of a General Economic Interest (SGEI) – but subsidy involved.
 - Meets Altmark criteria (see below).
 - Passive, neutral, open access, wholesale only, no special rights, subsidy only to non-profitable areas, provides “universal connectivity” in a given area.
- Presence of state-aid:
 - State aid for broadband: mandated, effective wholesale access for at least seven years.
 - State aid for NGA: they should observe the conditions for broadband, plus additional requirements that should be similar to those established by the National Regulatory Authority (e.g. passive and active access, conditions regarding migration to NGA). It should be noted that for white areas, both in terms of NGA access and basic broadband access, obligations concerning access to infrastructure, dark fibre and bitstream are required in any case.

When effective wholesale access is mandated, the Guidelines also establish that margin squeeze/predatory pricing situations should be avoided, by setting wholesale prices in line with (*ex-ante*) average regulated wholesale prices in competitive areas.

The Altmark criteria (based on case-law) are:

- 1) the beneficiary of a state funding mechanism must be formally entrusted with the provision and discharge of an SGEI, with its obligations clearly defined.
- 2) compensation parameters must be established beforehand in an objective and transparent manner.
- 3) the compensation cannot exceed what is necessary to cover all or part of the costs incurred in the discharge of the SGEI.
- 4) if there is no public procurement procedure, the compensation scheme must be determined based on the cost of a well run, typical undertaking.

Source: OECD elaboration from the “Community Guidelines for the application of State aid rules in relation to rapid deployment of broadband networks” (2009) and BEREC (2011)

It is remarkable that, as the BEREC report notes, there is no legal definition of the term “open access” in the whole European regulatory framework, but a general common understanding of the term by national legislators. Arguably, the notable exception to that are the Community Guidelines for public funding of broadband networks. These conditions are clearly prompted by the potential for public funds to be used to originate, or at a minimum perpetuate, situations of market power in a given area. The Guidelines only summarise the European Commission’s case-law on broadband state-aid and are therefore not directly applicable. The European Commission reviews each submission and decides whether it complies with the Treaty, and under which conditions.

The rationale for providing effective wholesale access to publicly-funded, or at least publicly-operated infrastructure, is clearly not exclusive of the European Union. As discussed below, many public utilities providing broadband services also offer open access, and so do structurally or functionally separated networks that have received public funding, such as Australia’s NBN and New Zealand’s FTTC network. Effective wholesale access is seen as a means to improving retail competition or, at least, creating the conditions for a contestable market where incumbents refrain from taking advantage of market power. At the same time, if these schemes result in a monopoly, or a virtual monopoly, at the wholesale level they will definitely require regulatory oversight.

Local and municipal networks

Regional and local broadband networks have played an important role in broadband provision in many countries. Local utilities have a significant advantage to deploy broadband infrastructure, as they can rely on existing utility networks, such as water, sewage or electricity infrastructure. Most of these deployments have some degree of involvement of public authorities, which may own municipal utility companies or operate them indirectly under public service concessions. These publicly-operated networks usually grant access on open, non-discriminatory terms, which may be termed as “open access”. It should be noted that the actual legal framework, under which these municipal networks operate, may take a wide variety of different forms including private-public partnership (PPP) arrangements.²⁵

In Sweden, much of the public funding in broadband networks has direct or indirect local government involvement in deploying broadband networks (Forzati et al. 2010). An estimated 95% of municipality networks and 42% of housing companies’ broadband networks in Sweden follow an open access model. TeliaSonera and Bredbandsbolaget are vertically integrated operators in that country. Most municipalities that owned a network also operated that network, as they found some difficulties in attracting ISPs. Swedish municipalities are often the only owners of the networks.

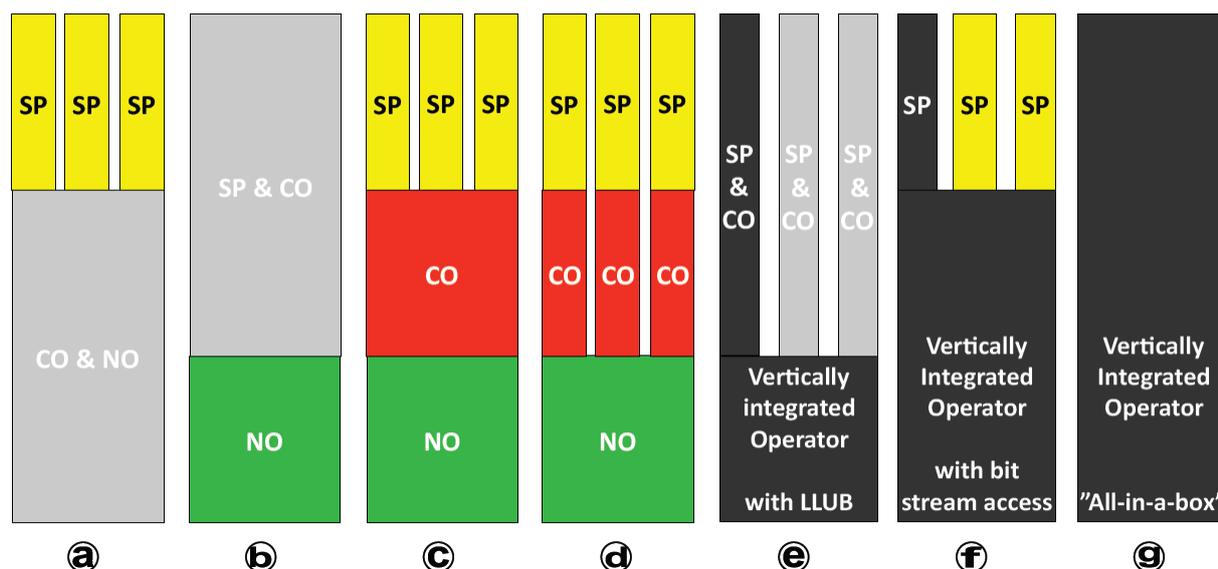
Stokab, owned by the city of Stockholm, runs a dark-fibre network and also acts as retail operator for the local government.²⁶ All operators are granted access to Stokab’s network on equal terms. Sweden’s largest housing company also belongs to the City of Stockholm and owns three companies: Svenska Bostäder, Stockholmshem and Familjebostäder.²⁷ The first relies on Stokab’s network but provides, in addition, passive infrastructure within the multi-dwelling units, whereas the active equipment is provided by communication operators. Other housing companies have similar business models even though they seldom host more than one communication operator on their networks.

One example of an open access model, operated by Mälarenergi, is found in the city of Västerås.²⁸ In this case the company - a utility owned by the City of Västerås - acts both as communication operator and network owner. By way of contrast, in the Säffle municipality, there is a municipality network, which only runs the infrastructure and contracts the operation of the network. This case is notable as TeliaSonera, the incumbent operator, is now acting as the communication operator. In Sweden, municipalities play a central role in public administration, including telecommunications, which is reflected in the active role they are playing in deploying fibre broadband networks.

Danish municipalities are not permitted to provide broadband services directly. However, privately-owned utilities, primarily made up of former municipality-owned utilities, are allowed to provide access to broadband infrastructure. Privatised utilities have therefore mainly focused on deploying local/regional broadband infrastructure. In fact, Denmark is one of the leading European countries in FTTH uptake as a per cent, of all subscriptions, with 13%, just after the Slovak Republic (30%), Sweden (28%) and Norway (16%). The type of utility providing broadband services and the level of involvement of the private sector varies from country to country, but municipal broadband networks are especially important in the Netherlands and some Nordic countries.

One study found that out of the 74 municipal utility broadband networks surveyed in ten European countries, just 6% provided wholesale services only, while 44% provided only retail services and 50% provided both (Troulos and Maglaris, 2011). Clearly, the established relationship between the utility and its customers favours the retail provision of broadband services. Several different arrangements are thus possible for the provision of broadband network services (see Figure 4), from a fully integrated operator (case g) to various arrangements among the network owner, the communications operators and the service providers. Due to the involvement of public authorities, European municipal and regional networks have to comply with the European framework of public funding of broadband networks.

Figure 4. Access networks business models



Source: Forzati *et al.* (2007), SP: service provider, CO: communication operator, NO: network owner.

Xarxa Oberta is a backhaul network deployed by the Catalan regional government in Spain.²⁹ It merges existing municipal networks and is directed towards self-provision of communication services to the regional and local governments, and a wholesale, open access network, which provides spare capacity on an independent, non-discriminatory and transparent basis.

One study compiled some experiences of municipal broadband networks in the United States (Lehr *et al.* 2004). They concluded that technical, economic and regulatory constraints influenced to a great extent whether open access is offered and, if so, what type (layer 1, 2 or 3). The study concluded the targeted market segment (*e.g.* residential, business), the network's footprint, the type of services offered (voice, video and broadband access or any combination of them), and so forth, depended on factors such as the legacy infrastructure and regulatory framework.

This study found little evidence of open access being adopted voluntarily (i.e. around 10% of 250-300 communities surveyed). It noted that those that do offer open access have been heavily influenced by regulatory policy in making that choice. For example, local or state-laws prohibiting entry in retail communication services (e.g. in the states of Utah or Washington). The findings from the United States experience with broadband municipal networks is that the actual arrangement and services provided by a municipal network are highly dependent on local- and state-level factors, such as the history of the utility, its relationship with customers and the specific legal framework in place.

Not all municipal broadband networks, in the OECD area, provide open access. Some have chosen different operating models. More specifically, for the “Progetto banda larga” of the province of Brescia and the “Firenze Wireless” project, both in Italy, a PPP was established in order to deploy a network offering both e-government and commercial services. Even though the network is publicly owned, its operation was awarded, through open procurement procedures, to private companies. In this setting, only one operator provides retail services, rather than allowing third-party provision through open access. By way of contrast, “Terrecablate Siena” follows a pure public utility model, where the network is owned and operated by a municipal utility, which can provide wholesale access services to other operators, even though not subject to open access requirements (Nuciarelli et. al., 2010). Wien Energie, a municipal utility in Vienna, Austria, runs a fibre network and provides wholesale broadband service (Blizznet) for third-party providers, including A1 (Telekom Austria), until 31 August 2011.³⁰ This network hosts multiple service providers. The company says that it provides non-discriminatory access to content and service providers. Customers can also freely choose the services they will sign up for.³¹ In Switzerland, Swisscom has developed interesting partnerships with the largest cities to deploy fibre networks (see Box 3).

Some companies like Axia (Canada) or Covage (France, participated in by Axia) have specialised in partnering with public authorities for developing PPPs for broadband infrastructure.³² Axia has been the successful bidder for the FTTH projects in Alberta (Canada), Catalonia (Spain) and Singapore, among others. Covage also bids for public procurement contracts for building and operating fibre networks, by selling wholesale communications services to operators.

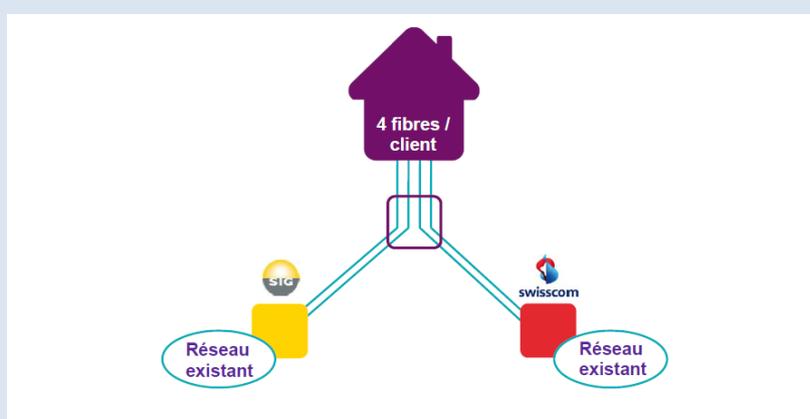
The Ons Net network, in the Nuenen municipality in the Netherlands, was successful in securing a municipal subsidy of USD 1 040 (EUR 800) per subscriber. This funding was transferred to the company responsible for deploying the networks (Sadowski et. al., 2009). The company was vertically integrated but open access was offered at Layer 3. Reggefiber became, in 2006, the majority shareholder of the operator. Despite being involved with public authorities in some projects, some of the networks deployed by Reggefiber did not involve public funding.

The available evidence on the business models for local broadband networks shows that open access conditions are provided by a large majority of the networks. They are rarely based, however, on voluntary arrangements, as they are influenced by local conditions, which may constrain the characteristics of the services they provide. Nor are they fully owned and operated by private players as most of them have a high degree of participation of public authorities in the form of various public-private partnership (PPP) arrangements. This is likely the result of the public ownership model used in some countries for municipal services such as water supply, sewage or electricity. These entities added broadband arguing they could do so at a lower incremental cost or provided a service not otherwise met by the market.

Box 3. The Swiss model for open access

Winterthur Utilities, in Switzerland, and the incumbent operator Swisscom have signed a partnership agreement to jointly expand the fibre network in the city. It aims at connecting 96% of households and businesses in Winterthur to a fibre (FTTH) network over the next few years. Swisscom will invest in the basic connection around 60% of the total cost (USD 77 million) and the city will cover the remaining 40%.

Swisscom has deployed a fibre network in the city since March 2010, and the already rolled-out cables will be incorporated into this partnership. Four fibres will be laid per household and business, and of these the two from Swisscom and the other two will be made available by Winterthur Utilities to other service providers, thereby enabling competition on an open infrastructure basis for the number of entrants that is technically feasible for this network. Swisscom has signed similar fibre roll-out partnership agreements with other municipal utilities, including Geneva, St. Gallen, Basel, Bern, and Luzern.



Source: www.swisscom.ch

Open access and general competition law

Beyond ongoing discussions on the role of *ex-ante* regulation and antitrust or merger reviews, these reviews undertaken by competition authorities in the course of an antitrust investigation, or a merger review, have the ability to frame markets and provide a level playing field for competition. As such, some antitrust and merger decisions have been crucial in implementing pro-competitive policies. Sometimes, they can make options available to enhance the ability of a regulator to impose conditions on market players, which otherwise may not be possible. This can be justified if there would otherwise be a diminution of competition resulting from a merger or acquisition between two firms.

In January 2000, American Online (AOL) and Time Warner announced a merger, which was subsequently submitted to the FCC and the Federal Trade Commission (FTC) for review in the United States. The merger was approved, under some conditions imposed by the FCC, a year later.³³ At that time, the 1996 Telecommunications Act had been passed and its implementation process was proving to be challenging, given various lawsuits questioning the FCC's authority to impose open access conditions, especially line-sharing and mandatory unbundling.

The conditions imposed on the merged entity can, therefore, be seen as an additional instrument used by authorities to impose undertakings to promote competition. In particular, the FCC ruled that AOL Time Warner should be prevented from constraining customer choice of ISP, over its cable network. The merged entity was also required to allow ISPs to control the first screen that consumers call up when they access

the Internet via a competing service, and to require it to give unaffiliated ISPs the same quality of service guaranteed to affiliated ISPs.

This decision should be considered, however, in the technological and market context of the time. Dial-up Internet access, via ISPs such as AOL, was still largely provided over networks owned by separate entities, such as via the public switched telecommunication network (PSTN). The operators of the PSTN were governed by rules that had been established to enable liberalisation of what were then broadly called value added services. The providers of these telecommunication networks could offer similar services to ISPs but had to create separate or stand-alone entities to do so. While dial-up services are still used by a very small number of Internet access subscribers this model was largely overtaken by changes to regulation and the development of commercial models that bundled broadband access and services. Nonetheless the intervention by the FCC and FTC provides an example of regulatory authorities using a merger to impose open access requirements.

The Netherlands provides a more recent example of open access conditions that have resulted from a merger review. In this case, the decision was issued in the context of NGA developments, and is aimed at ensuring long-term competition. The KPN-Reggefiber joint-venture was approved by the Dutch National Competition Authority (NCA), under certain conditions (Box 4).

Box 4. The KPN-Reggefiber joint venture and its attached open access obligations

The decision of the Dutch competition authority (NMa) on the KPN-Reggefiber remains one of the few competition cases in telecommunications where open access obligations have been imposed on the merged entity. It is also regarded as a good example of co-operation between a competition authority (NMa) and a telecommunications regulator OPTA.

Cable companies UPC and Ziggo have close to nation-wide coverage with non-overlapping footprints. These companies have developed over the years a significant competitive threat against the incumbent KPN. Reggefiber is a new entrant in the Dutch telecommunications market. It has deployed fibre broadband networks across the country and consolidated some of the existing local utility fibre networks. The joint-venture was formed to leverage KPN's customer base and marketing expertise and Reggefiber's network capabilities.



It was determined that the resulting entity would decrease competition both in the fibre and in the copper broadband market. Moreover, when the latter was replaced by fibre, there would only be two alternative networks in the country: fibre and cable (UPC's and Ziggo's cover different areas). These competition concerns were addressed by NMa by means of some undertakings, including open access requirements.

The merged entity had the following conditions imposed by authorities: *i)* to keep the joint-venture separate from its parent companies; *ii)* to provide information about the roll-out planning to (potential customers); *iii)* to grant access to third parties on specific terms; *iv)* transparency (including a reference offer) and non discrimination; and *v)* price caps, minimum quality of service and enforcement procedure.

The KPN-Reggefiber example highlights one of the challenges of converging antitrust and regulatory frameworks. The main concern, in this case and possibly others, was the potential conflict between the two sets of remedies. In a similar manner, the same problem could arise from obligations imposed in the context of public funding of broadband networks. These potential conflicts can be the result of various regulatory frameworks addressing a case from different perspectives. In the Dutch context, the competition authority NMa and the telecommunication regulator OPTA engaged in extensive discussions about how best to regulate the resulting entity and both authorities agreed a common response.

Merger review provides an opportunity for countries to impose certain conditions that cannot be based on general *ex-ante* regulation. This procedure should however remain extraordinary as it is case-specific by nature. If countries are aware that their telecommunication regulators lack the appropriate tools to ensure a level playing field and, if they wish to do so, impose open access obligations, they should consider developing the appropriate legal instruments and not rely on the opportunities offered by merger review.

Inter-agency conflicts arise in many OECD countries and should be considered based on different expertise, history and cultures of the two organisations. Ideally, public funding bodies, competition authorities and telecommunication regulators should engage in exchanging views and eventually agreeing on a common decision based on mutual understanding of the issues they are facing. At a minimum, these agencies should develop exchange protocols, or Memoranda of Understanding whereby they ensure the consistency of the conditions imposed on mergers or public funding with the telecommunications regulatory framework. Issues like wholesale pricing if “open access” agreements are imposed are crucial and the different agencies should convey a message of coherence, regulatory certainty and mutual co-operation.

Wireless open access

In recent years, wireless networks have become increasingly used in the delivery of traditional and some new communication services. Following increased transmission speeds and smartphone uptake, wireless broadband services are becoming more essential for the development of broadband networks. Some of the potential advantages of wireless networks include faster roll-out, potential wider subscribership, due to higher smartphone uptake, and a lower cost of deployment in rural and remote areas. In addition, of course, is the potential benefit of mobility for users. Nevertheless, wireless services are largely complimentary rather than competitive with fixed NGA networks.

The major limitation with wireless broadband is that spectrum is a scarce resource. OECD countries have only granted a limited number of Mobile Network Operator (MNO) licenses, typically between three and five. The bands assigned to operators need to be wide enough to allow for efficient spectrum use, avoid fragmentation and be capable of transmitting high-speed data. This is why the number of players and the available bandwidth play a key role in wireless markets and the degree of competition that exists.

In most countries with MVNOs, regulators have refrained from mandating that MNOs give MVNOs open access to their networks. According to some authors, the voluntary relationships or purely commercial agreements between MNOs and MVNOs emerge when they are mutually beneficial and there are no obstacles for these agreements to be reached (Dippon and Banerjee, 2006). These cases are, for instance, when the MVNO can add value to that relationship in ways such as expanding the MNO-served market and helping boost the combined profits of MNOs from retail and wholesale services beyond the likely profits from retail operations alone. For example, TracFone in the United States, which is the largest MVNO and larger than every facilities-based provider other than the four nationwide providers, offers prepaid mobile wireless services through commercial agreements with about ten wireless service providers in the United States, including AT&T and Verizon Wireless.³⁴ The largest facilities-based providers are arguably using strategic partnerships with TracFone in order to compete with each other for customers.³⁵

In other cases regulated access to spectrum resources, such as through “open access” agreements, aims at achieving a greater level of competition in wireless markets by addressing spectrum limitations to the number of MNO licenses that can be issued. Experience has shown that, in a market where there is limited opportunity for market entry, MNOs have often shown little appetite to lease spectrum to potential competitors (i.e. mobile virtual network operators or MVNOs). For these arrangements to make commercial sense in terms of providing increased competition, MNOs must provide access to competitors at a price that cannot be higher than what MNOs could charge its own retail business. There might be other cases based on commercial agreements, however, where the MVNO may be able to provide a compelling value added service for users. To create a mutually beneficial situation, MVNOs would refrain from offering perfectly or even near substitutes for their host MNO’s services, and try to develop retail services and market segments that MNOs largely ignore. This leads to situations where MVNOs provide value added services to niche customer segments (e.g. “greatcall” in the United States focusing on senior mobile users, Red Pocket Mobile in the United States providing multi-language customer support to foreign communities).

From a regulatory perspective the introduction of MVNOs has, of course, been to try to address the spectrum constraints that otherwise exist for market entry. Among them, we can mention “full MVNOs” who own and operate the core network elements, but do not have spectrum licenses. Instead, they can lease network infrastructure from MNOs or buy wholesale access or airtime from MNOs in order to provide services. Other MVNOs do not own all the core elements of the mobile network and this has proven to be a limitation to their ability to introduce competition in areas such as international mobile roaming.

Regulators need to balance open access policies against the incentives for different actors to invest in infrastructure and services. Too often this is presented as a trade off between increasing competition and a potential negative effect on investment. If open access policies can be introduced in a way that facilitates new investment, and drives incumbents to respond in kind, it is beneficial for the overall market. In France, for example, a new mobile market entrant came into the market at the beginning of 2012. Without an obligation for national roaming, on a pre-existing network, the new operator would have faced an almost impossible challenge, until it was able to roll out sufficient infrastructure to attract users. The regulator intervened in two ways. One was to compel existing operators to make available a commercially negotiated national roaming offer and the other, to specify the new entrant had certain targets it had to reach to initiate this offer (*i.e.* 27% of national coverage).

While existing operators, in any market, rarely welcome new entrants the existing incumbent offering roaming services to the new entrant has said it expects it could raise double the amount of revenue originally predicted (*i.e.* USD 2.6 billion instead of USD 1.3 billion).³⁶ These figures depend, however, on the pace at which the new entrant can roll out infrastructure where it currently uses the incumbent facilities. Clearly, it has an incentive to invest and thereby reduce payments to the incumbent for national roaming. Meanwhile the balance achieved by the regulator has brought considerable new competitive forces to the French market and new innovation. Such a balancing act can be more challenging with MVNOs.

Interventions giving entrants and competitors network access on a non-discriminatory basis and at cost-based prices might discourage investments to expand or upgrade their network infrastructure, as any competitive advantage arising from these investments would be available to hosted MVNOs while the associated risks would be borne by MNOs exclusively. Given the choice, open access that promotes and increases infrastructure competition, as is currently happening in France, may be preferable but cannot always be an option due to the availability of spectrum. That is why MVNOs play a very useful role but one that rarely transforms a market in the way a new entrant with their own infrastructure can achieve such a change.

The amount of innovation any market participants can generate is dependent on their own infrastructure, in the case of network facility providers, or the degree of open access provided for entities that resell services. In other words innovation can be closely tied to the network layer at which providers have control of their own services. To build on the example, in France, the new mobile entrant launched Extensible Authentication Protocol, or EAP, for its customers three months after joining the market. The service allows seamless authentication for its mobile users to its fixed network Wi-Fi service via xDSL or Fibre connections (see Box 5).

Open wireless network access is often discussed in the context of regulation that will require dominant operators (or operators with significant market power - SMP in the European Union terminology - to make their infrastructure available to other players. At the European Union level, the Access Directive stipulates that all public communications network operators shall have the right and obligation to negotiate interconnection with each other on non-discriminatory conditions, when requested by others.³⁷ Furthermore, operators who are declared as having market power may have obligations imposed on them “to meet reasonable request for access to, and use of, specific network elements and associated facilities” by national regulatory authorities. Thus, dominant players may sometimes, but not always, be required to observe open access network rules - *i.e.* provide access to networks or network facilities to all market participants on a fair and reasonable basis.

Box 5. Open access and home-based Wi-Fi networks

In 2012, a fourth facilities based network operator entered the mobile market in France (Iliad's Free Mobile). Initially, like many mobile operators that also own fixed local access networks (or install them at locations such as coffee shops and airports), Free enabled its mobile subscribers to access the facilities of its fixed network to take advantage of their Wi-Fi capabilities, if they were also fixed network subscribers. Mobile operators do this because it enables them to offload traffic from wireless to fixed networks, lower costs and improve services to customers.

Like a number of operators, Iliad has also provided the option for its fixed broadband subscribers to share their Wi-Fi with others on its network. In the case of Free Mobile this was available from day one of the service though customers had to sign on and authenticate their subscription to gain access. Soon thereafter, Free Mobile switched on the EAP-SIM protocol. This enabled Free Mobile subscribers to access Wi-Fi automatically via authentication using their SIM card. This included the advantage of more convenient access to potentially better network performance for those accessing services via Wi-Fi as well as freeing capacity for those still on the 3G network. In addition, data sent or received over Wi-Fi does not count towards a user's 3 GB monthly cap.

Free's business model has a number of features that have been derived from open access policies and practices. The company provides broadband, television and telephone services using local loop unbundling and its own infrastructure, and has persuaded its customers that they would benefit from sharing their Internet connections, as part of a bottom-up open access tool so as to expand its nationwide Wi-Fi network. Having achieved this, Free is now opening the free Wi-Fi to mobile customers, even those without fixed broadband subscriptions.

This provides further benefits. The company is not only able to offload traffic from mobile to fixed networks, but also to potentially reduce the amount of roaming payments to the incumbent operator. In that sense, it is using open access granted on a voluntary, though mutually beneficial, basis by its fixed network customers to substitute for the use of some regulated access imposed on an existing operator (*i.e.* while Free continues to roll out its own wireless coverage).

In its most recent update of the Recommendation on relevant markets (December 2007), the European Commission removed the mobile access and call origination market from the recommendation, suggesting that these markets were generally competitive in the European Union, unless national regulatory authorities considered otherwise. In this respect, various European countries have imposed obligations on the mobile access and call origination markets, aiming at facilitating entry and operation by MVNOs as well as better network utilisation if network capacity tends to be under used.

Indeed, MVNOs have flourished in some countries either by voluntary arrangements or due to some degree of regulatory action. In some countries like Denmark or Spain they have played a key role in market dynamics by increasing the number of players in those markets, by favouring players covering specific market niches (e.g. by adding specific value added services such as language support) and by promoting price-based competition

As opposed to that, the French regulator ARCEP found that, as of 2004, the mobile access and call origination market was not sufficiently competitive and that MNOs had a common interest in avoiding wholesale agreements with MVNOs. Thus, the regulator proposed new legislation mandating wholesale access as a way of stimulating competition. Since the proposal was made, however, French MNOs have voluntarily signed contracts with MVNOs for network access and, in view of these agreements, the regulator withdrew the proposal.

Despite this decision, renewed concerns have arisen in France regarding the competitive role of MVNOs.³⁸ In the recent frequency allocation in France, the condition of hosting MVNOs, upon a reasonable access request, was one of the tender criteria. The regulator conceived the issue as an important contribution to competition dynamics and placed particular value on the MVNO-related commitments. The spectrum assignment procedure was designed in a way that making a commitment to hosting of MVNOs was one of the selection criteria, in addition to any financial amount bid for the frequencies. Thus, successful bidders are forced to open up their network to MVNOs. A similar set of requirements was observed in the recent frequency allocation in 900 MHz in Japan.³⁹

In Norway, the regulator NPT conducted the three criteria test for the access and call origination mobile market in 2010 and decided to extend *ex-ante* regulation.⁴⁰ Based on the NPT's market analysis and decision, Telenor was designated as an SMP operator, and must thus meet all reasonable requests for access and call origination on its mobile network regardless of the form of MVNO access, national roaming and collocation, on a non-discriminatory basis without undue delay.

If regulators find that markets are effectively competitive, no on-going *ex-ante* regulation is warranted. For example, Denmark used to impose on TDC an obligation in this market to provide wholesale access and national roaming for other service providers (including MVNOs) on objective, transparent and non-discriminatory terms. Thus, TDC was under general open access obligations where the company had to grant all reasonable requests for wholesale access. These rules were revoked after the 2007 Commission Recommendation came into force, as the Danish regulatory authority found that there was effective competition in the market and no need for *ex-ante* regulation that was previously imposed on TDC.⁴¹ In the United Kingdom, OFCOM has stated "the mobile market continues to show signs of healthy competition and we do not currently see strong evidence of the type of market failure that drove our major intervention in the fixed sector". These countries would apply *ex-post* competition law rather than *ex-ante* regulatory obligations in order to address any emerging problems.

In other countries, open wireless network access is considered in the general context of network operator's obligations instead of operator-specific or case-specific requirements. In Japan, MNOs are, as fixed telecommunication carriers, required to provide access to any requesting carriers and subject to relevant interconnection obligations (e.g. fair, cost-based and non-discriminatory basis, making access charges and terms and conditions publicly available). To promote market entry by MVNOs, the Japanese government has been strongly involved in access policies for mobile markets and published some guidelines in 2010. Authorities were encouraged by the beneficial experience the country had achieved with unbundling policies for fixed networks.⁴²

More generally, the adoption of NGNs drives these two sectors - i.e. fixed and mobile networks - towards convergence. The two networks will carry similar applications and share the same transmission protocol. The regulatory experiences in fixed NGN could be also applicable to mobile NGN. The growing take-up of mobile broadband services may increase the demand for network access from a variety of players in a more flexible manner, which could help develop more innovative services.

Hong Kong, China, also has general open access regulation in the mobile market.⁴³ Although limited to 3G network licenses, the regulation requires MNOs to open 30% of their 3G network capacity to non-affiliated service providers (e.g. non-affiliated MVNOs) on a non-discriminatory basis. The regulator OFTA has stated that the objective of this regulation is to promote competition for the provision of content and services over 3G networks, and to enable operators that do not have the resources to bid for, or who have failed to obtain 3G spectrum, an opportunity to participate in the 3G business. Thus, non-affiliated MVNOs may have access to the same network capabilities that the host MNO has made available to its own customers or affiliated service providers. Once an MNO has reached the open-network access threshold, it has no further obligation to provide additional capacity to non-affiliated MVNOs already connected.

Another approach is wholesale-only wireless broadband networks, purely commercially driven and not based on open access regulatory obligations. Lightsquared, in the United States, is attempting to implement a business model that would provide wholesale wireless network services, with national LTE coverage. This approach would focus on providing wireless access to market players which do not have their own wireless network or have limited spectrum resources. As of March 2012, the network deployment plan has been suspended, however, due to possible harmful interference with GPS services. The National Telecommunications and Information Administration (NTIA) of the United States concluded that there is no practical way to mitigate this interference from the company's planned terrestrial operations.⁴⁴ Lightsquared filed for bankruptcy protection in May 2012.

Infrastructure sharing could also be discussed in the context of open network access. In general, it is expected to avoid investment duplication or decommissioning of redundant sites and enable time-saving and efficient use of resources. It also has benefits for environmental and urban planning as it reduces the number of sites and space needed. Thus, infrastructure sharing is becoming an important means of promoting access to networks and offering affordable broadband services by reducing expenditures and ongoing expenses associated with the rollout and operation of networks.

There are generally two types of infrastructure sharing, either "passive" or "active". Passive network elements include cell towers, roof sites and power supply while active element sharing involves network controllers, switching and transmission systems. The latter might be more challenging due to a higher technical complexity, which may constrain the possible maximum speed provided. In recent years, there has been a trend towards infrastructure sharing in the mobile sector on an open access basis. For example, American Tower owns mobile tower sites all over the world and provides commercial access to towers for mobile operators.⁴⁵ GLT Infrastructure has a portfolio of over 30 000 mobile towers in India and sells shared passive infrastructure to mobile operators.⁴⁶

Some countries have adopted policies to actively promote infrastructure sharing in the mobile sector. In Austria, under the Telecommunications Act, owners or other authorised users of a mast are required to permit joint use by public communications network operators if this use is technically feasible, in particular in terms of signal interference.⁴⁷ In Denmark, the Mast Act stipulates that masts owners for communication purposes have to meet requests from other parties for joint utilisation of the masts.⁴⁸ In other countries, the regulators rely on operators to engage in commercial negotiations for infrastructure sharing.

Given the increasing number of innovative services that have become available in mobile markets, some OECD countries are considering ensuring openness and flexibility of network intelligence functions. For example, VoIP are now directly available to consumers, provided by independent providers or smartphone applications, regardless of the operator that provides wireless connectivity.

In Japan, the government is now considering the inclusion of certain network intelligence elements under the scope of unbundling requirements. On the other hand, the United Kingdom acknowledges that network intelligence functions will be gradually replaced by “intelligent” software applications.⁴⁹ For instance, Google’s “My location” collects data about user location by taking information from cell towers close to users to estimate their current location. Its capability of showing user location without accessing mobile operators’ information database underlines this trend. Whether the role of network intelligence will increase or diminish is unclear, but it is important that policy makers and regulators monitor market developments carefully and take actions if needed.

Spectrum is one of the critical issues in view of the growing demand for connectivity. Many OECD countries are reconsidering their fundamental spectrum policies by finding alternatives to traditional approaches. More flexibility, to accommodate market changes quickly, may be needed. For example, one of the new options may be the various forms of “sharing”, as spectrum may be shared in various ways based on time, space and geography. In the OECD area, one of the most common schemes for spectrum sharing is unlicensed spectrum. Here no single entity has an individual licence for that part of the spectrum and it is allocated for open use. There are, of course, rules, including technology restrictions and power level limitations, to avoid interference. A completely open system may, of course, have risks associated with a “tragedy of the commons”. However, the recent outstanding success of Wifi and wireless LAN indicates that this approach has merit when considering efficient and flexible use of scarce resources and further technological developments may enhance the application of shared spectrum.

At the European Union level, there is an ongoing discussion on opening spectrum for wireless communications in the context of the “Digital Agenda for Europe”. The original proposal of the European Union Parliament was in favour of an open access spectrum where appropriate, which would be harmonised at the European Union level. This included fostering shared and unlicensed spectrum use. As in other parts of the world the idea is to build on the success of open access Wifi. If spectrum can be used more flexibly on a shared and unlicensed basis depending on demand and technical feasibility, more affordable services may be possible. Innovative spectrum policies may also help expand wireless network coverage especially in less populated areas, which could assist in tackling that aspect of the “digital divide”.

In other cases, unlicensed “open” access to spectrum has been discussed in the context of “white spaces”. Spectrum allocated to television broadcasting generally has good propagation characteristics, which could promote innovative mobile devices and services. Wireless broadband providers are also expected to expand and improve service coverage especially in rural areas more easily with less expense. In the United States, the FCC allows unlicensed operation in the television bands at locations where frequencies are not in use by licensed services.⁵⁰ This has permitted both fixed and personal/portable unlicensed devices to operate in the television bands under certain technical conditions.

Open access obligations or policies are relatively new to the mobile communication industry, which, unlike fixed networks, has benefitted from arguably a greater degree of “end-to-end” competition. Across the OECD there is generally between three to five MNOs offering services in the same areas. By way of contrast, a user in a suburban street may only have one or two fixed network providers with their own facilities. For this reason there has generally been greater use of open access policies in fixed rather than mobile networks. On the other hand, spectrum constrains new market entry and joint ownership of fixed and mobile operators can also limit the pool for intermodal competition. This is why some countries have

encouraged or mandated open access schemes, which usually take the form of MVNO access. Where these developments have taken place, they can be considered to be relatively successful for domestic markets though they have had little influence on the price of international mobile roaming. This is because open access policies, imposed by national authorities, tend to be limited to domestic services.

Infrastructure sharing agreements are playing an increasingly important role in mobile markets, more markedly in the context of the deployment of LTE technology. Wholesale-only models have emerged at different levels of the network (*e.g.* Lightsquared, American Tower) and are usually based on purely commercial arrangements. The expected level of investments required for the deployment of LTE networks is clearly encouraging these agreements. The increasing focus on infrastructure sharing, or even mandated sharing, could however potentially reduce competitive investment incentives for network roll-outs. This means a likelihood of a virtual monopoly for some infrastructure with the attendant implications for required regulatory oversight.

A Russian mobile operator (Yota) reached an agreement, in March 2010, with four mobile operators in the country, to roll out one single wholesale LTE network that will be utilised by the four operators on a wholesale basis.⁵¹ By 2014, the network is expected to cover 180 cities with more than 70 million inhabitants. The four operators also have had the option of a future stake of 20% in Yota. The agreement indicated an arrangement for the separation of network ownership and service provision. The stated aim is to avoid the cost of duplication of infrastructure investment and provide users with faster mobile access at lower prices.

In a similar development to Russia, and in the context of a single national open access LTE network, the Kenyan government has launched an initiative to roll out a wireless network. This will be funded and used by a single “consortium”, including participation of the main telecommunication operators.⁵² The ownership structure is based on a public and private partnership (PPP) where the government and telecommunication operators will own stakes equivalent to the capital they will invest in this joint venture. The government plans to issue a tender for a new company to build and operate the wholesale network, as opposed to auctioning the spectrum and awarding mobile licenses to individual operators.

These developments, in mobile networks, can be considered under the scope of infrastructure sharing agreements or, in the case of voluntary MVNO arrangements or other wholesale deals, under purely commercial schemes, unless some transparency and non-discrimination clauses are added to these agreements.

Internet exchange points, submarine cables and wholesale backbone networks

The exchange of traffic between different networks is fundamental for ensuring communication between users of different networks. With the expansion of the Internet, Internet exchange points (IXPs), where ISPs exchange Internet traffic among their networks, play a critical role in providing more efficient and cost-effective interconnection. The alternative is “transiting” the traffic through a third party to be exchanged and delivered back to the terminating network. In many countries, before the establishment of IXPs, traffic between two local networks would be exchanged outside the original country or region. This potentially had a negative impact on transit costs and network performance. The establishment of IXPs enabled these costs to be reduced, and network performance increased. Furthermore, by concentrating supply and demand they created a competitive marketplace for Internet transit around the IXP, which resulted in lower prices. In many OECD countries transit prices have dropped by a factor of 100 or more since 2000.

IXPs enable the efficient exchange of local traffic and therefore reduce the payments to upstream providers, traffic route distances, and latency issues experienced by end-users. Mexico is the only country in the OECD area without an IXP. Internet traffic originated in Mexico is exchanged on the east coast of the United States, in Latin American countries or European countries. In 2012, the OECD found that Mexico is among the most expensive countries in terms of IP transit charges.⁵³ Broadband prices paid by consumers and business necessarily reflect these IP transit charges and thus contribute to higher broadband prices. The insufficient use of IXPs, in a given country, is not in the interest of business and consumers. Generally, this points to a lack of competition in some aspect of the market. Concerns have been raised in Chile, for example, due to the common practice of exchanging traffic through the United States, despite having several IXPs in that country. If different actors do take this path it would tend to indicate either a problem with the local governance of an IXP (the best are self regulated and voluntary) or some other bottleneck that ISPs, using offshore facilities, are seeking to bypass.

IXPs in the OECD area are not regulated by government policy, and transactions within an exchange are left to market forces. Efficient IP-based interconnection can be achieved without the need for regulatory intervention. Because no entity is able to connect to the worldwide Internet on its own, a series of interconnection agreements and IP traffic exchanges constitute traffic routes which will reach its intended destination by means of “peering” or “transit” agreements.

Peering is a way to transport traffic between two networks, settlement-free in most but not all cases. By way of contrast, transit is used to transport the traffic via a paid agreement (e.g. from an ISP to an upstream service provider). These schemes rarely need regulatory oversight, since there is usually a fair range of peering and transit agreements to choose from. Two or more ISPs interconnected by the same public peering agreement are usually referred to as an “Internet Exchange Point”.⁵⁴

One way to ensure openness at the IXPs is called “mandatory multilateral peering” agreement where every connected party at an IXP must peer with every other party who is connected. Under this voluntary agreement, all connected parties agree to exchange traffic under the same conditions in the same agreement.

The downside of this type of agreement however might create a disincentive for large ISPs to interconnect. For example, the Western Australian Internet exchange (WAIX), requires a mandatory multilateral peering agreement among participants and, thus, every participant has to peer with every other participant.⁵⁵ This operational rule of WAIX influences the composition of participants. On the one hand, it has attracted many small and non-ISP participants; on the other hand, large ISPs such as Telstra and Optus are not parties to the agreement. These larger operators would prefer to sell transit to the smaller operators, which they say provides a return on their investment in the infrastructure for this traffic to be conveyed. This system works best if operators, small or large, have the freedom to choose their own arrangements for peering or transit.

The Kenyan IXP (KIXP) is run and operated by a non-profit organisation representing the ISPs and other telecommunication service providers in Kenya (the Telecommunication Service Providers Association of Kenya). It is a mandatory multilateral peering agreement, and each member must have a peering session with every other member through the KIXP route servers and router reflector.⁵⁶ The KIXP is a very unique case in that the regulator grants the license to the IXP operator (see Box 6).

Box 6: Government involvement in the Kenyan IXP

KIXP was launched initially in 2000 when the market was not yet fully liberalised. Following its launch, the incumbent telecom operator, Telkom Kenya (TK), filed a complaint before the national regulator and argued that the KIXP violated TK's exclusive monopoly on the carriage of international traffic. The regulator concluded that the KIXP be shut down as an illegal telecommunications facility. TK's opposition to KIXP was fierce because of the fear of losing a significant portion of its international leased line revenues.

Following discussions with the regulator, KIXP was granted a licence in November 2001. In 2002, the KIXP was re-launched having interconnected five Kenyan ISPs as the licence KIXP received stated that only licensed ISPs could participate in the exchange. Subsequently, the government has permitted KIXP to accommodate data providers that are not formally licensed ISPs with an interest in helping the exchange grow.

To date, there are 25 members already peering at the KIXP. Relative to major IXPs, the throughput of traffic exchanged is low, while it ranks among the top 15 IXPs in terms of growth, with 150% on an annual base.

Source: The World Bank (2011), Broadband Strategies Handbook

In Chile the regulator requires all IXPs in the country to be interconnected among themselves.⁵⁷ As the participation of large ISPs may have an influence on the success of IXPs, governments may consider facilitating the development of IXPs but as there have been questions about “tromboning” domestic Chilean traffic through third countries, it raises the issue as to whether such regulation is efficient. Some may ask about the effectiveness of such an obligation for openness to all participants, regardless of whether it is based on government involvement or industry voluntary agreements, since it might provide the wrong incentives, (e.g. ISPs may not expand their facilities to connect beyond a single exchange and hinder growth of the other IXPs).

The Neutrinx IXP in South Africa, which opened in September 2011, provides non-discriminatory, transparent interconnection among its parties.⁵⁸ This is an example of “open policies” for potential members to join the IXP. The Northwest access exchange (NWAX), established in Portland, Oregon, in the United States is another example of an Internet Exchange run by a neutral, non-profit organisation.⁵⁹ NWAX notes in its website that if a network service provider both operated the exchange and offered commercial network services, then other providers would be reluctant to join the exchange based on concerns of an uneven playing field.

In other cases, non-profit Internet-related institutions have undertaken major steps to improve broadband connectivity through IXP arrangements. For example, the Canadian Internet Registry Authority (CIRA) has undertaken an active programme to help qualified communities, independent ISPs, regional research and education networks and others to deploy IXPs in their community. CIRA's overall goal is to have local members build and operate the IXP, with CIRA bringing technical expertise, stability, back office functions, governance assistance, content providers and, if required, some financial and equipment support. Most significantly CIRA will help the IXP provide a variety of DNS hosting services (which can improve responsiveness and reliability for connected users) as well arranging CDN networks to collocate at the facility.⁶⁰

Many IXPs are run by non-profit, neutral organisations of network operators, some with a small degree of government involvement, and have a clear, open policy for new members to adhere. The costs, usually shared among the parties, are sufficiently lower than those that would be incurred through multiple peering agreements or through transit to make these IXPs efficient. Therefore, it could be argued that IXPs provide an example of voluntary, open access arrangements, in that they enable efficient, non-discriminatory and cost-effective wholesale connectivity among ISPs. It should be noted, however, that

IXPs may rather be regarded as entities that facilitate interconnection between ISPs, rather than as arrangements providing access to infrastructure.

Wholesale open access: fibre backbone

The previous sections have largely dealt with wholesale open access for access and backhaul networks. This is linked to the location of the main economic bottlenecks in telecommunication networks: local access and backhaul tend to be more problematic in terms of effective competition as there is generally much more competition in national and international backbone networks. In some countries, however, wholesale backbone networks, may also involve economic bottlenecks in certain cases.

A lack of overseas connectivity through submarine cables has, in the past, been reported as a major hurdle for the development of international connectivity in some parts of Africa. Brazil has proposed the construction of a regional fibre backbone network to lower international connectivity costs in South America. In Europe, some routes have also suffered from insufficient competition, for example between the European mainland and some islands like the Spanish Canary Islands or some French DOM-TOM overseas territories, such as Mayotte, or some undersea cables between Europe and Africa (see Box 7).

Backbone fibre connectivity is perceived as a major problem by many governments. South American countries have long been aware of the problem, as wholesale backbone connectivity costs represent a higher share of the final retail costs than in most other regions at an estimated 30-40%.⁶¹ Last March 2012, UNASUR Ministers met in Asunción, Paraguay, and agreed to a roadmap for a regional fibre backbone infrastructure.⁶² The agreement lays down a three-year roadmap for UNASUR countries to develop a fibre ring including undersea cable connectivity. The first steps of the roadmap are planned to identify existing public and private backbone infrastructure and design an interconnection map.

Until recent years, Africa's Eastern Coast was an area without fibre-based international connectivity. This meant Internet users had to rely on more expensive satellite communication facilities for backbone carriage of traffic. Essay is a consortium that identified the need for connectivity in the region and deployed a 10 000 km submarine cable system linking South Africa with Sudan, including landing stations in Mozambique, Madagascar, the Comoros, Tanzania, Kenya, Somalia and Djibuti, with an estimated cost of USD 263 million.⁶³ It started operation in July 2010 and is run by a consortium of African telecommunication operators, through a public-private partnership WIOCC (West Indian Ocean Cable Company Limited), a special purpose vehicle (SPV) that benefitted from development funds. The consortium advertises "non-discriminatory open access" for small and medium telcos, ISPs and other organisations.⁶⁴

Box 7. An alternative undersea cable to the Canary Islands

Given its geographical location, the Canary Islands in Spain have experienced competition concerns and deficient connectivity to Spain's mainland and to the rest of Europe. Telefónica was, up to 2008, the only provider of undersea cable connectivity between the Canary Islands and the Spanish mainland territory. Wholesale connectivity prices have been regulated since 2008. Canalink, a consortium of IT3, a publicly-owned telecommunications operator, and Islalink decided to invest in an alternative 2000 km-long undersea cable between the Canary Islands and the Spanish mainland.



This project is part of the broader initiative ALIX, which has been launched by the local authorities. ALIX aims at creating a Neutral Access Point (NAP) in Tenerife (Canary Islands) for Internet connectivity between Africa, Europe and America. As the project involves publicly-owned operators entering the market, the Spanish regulator (CMT) resolved that the new operators must observe the principles of neutrality, transparency and non-discrimination.

Source: NAP/WACI and www.d-alix.com

In its “*Rapport au Parlement et au Gouvernement relatif au secteur des communications électroniques outre-mer*” –on overseas French *départements*-, the French regulator ARCEP states that one of the reasons for the insufficient broadband development in DOM territories is the weak competition in undersea cables.⁶⁵ ARCEP recommends the purchase of long-term rights of use (so called indefeasible rights of use or IRUs) as opposed to leasing cable capacity to decrease the costs for operators and thus favouring the entry of alternative operators. A number of public initiatives for deploying alternative cables and granting access to alternative operators are taking place in the Antilles (Guadeloupe, Saint Martin and Saint Berthélemy) and Mayotte.

In some countries with more strict licensing regimes, the legal requirements for license holders may be a barrier to the development of “open access” wholesale backbone providers. For example, Chile recently modified its licensing regime to allow for wholesale-only providers. Previously, only those operators providing retail communications services could apply for a license, which virtually impeded wholesale-only business models for telecommunications.⁶⁶

Open access policies for backbone connectivity, including undersea cables, have historically rarely been the outcome of purely private or public initiatives. In undersea cables, for example, while access for participation in IRUs might have been relatively open, in some cable systems, this did not mean much if

national regulation precluded competitive operators from taking advantage of connection to landing points for a specific country. At the same time, open access policies can be pro-competitive, irrespective of the nature of participants.

Common elements of open access policies

The previous sections provide an overview of the main elements of open access (or open access-related) policies and on the common elements present in these arrangements. The first conclusion, that may be drawn, is that there is no generally applicable legally-binding definition of “open access” in OECD countries. This term is widely used, sometimes with different implications, by a broad range of stakeholders, including public authorities. In its widest scope, “open access” is used to designate the use of a network by a third party other than the owner/operator of that network.

The second conclusion is that open access arrangements are applicable to access, backhaul and backbone networks and are therefore not dependent on the underlying technology or network level. Some of the common elements can be found at any of these levels. Accordingly, the use of the term “open access” for broadband networks can be linked to the following properties, or common characteristics, that are usually present in those arrangements.

Wholesale access

There is a widespread agreement among stakeholders and across all types of technologies that “open access” refers to wholesale access. Nonetheless, (*ex-ante*) regulated wholesale access is only one area where open (wholesale) access can take place, as open access may also happen as a result of a voluntary decision of a single network to provide it.

Effectiveness

Wholesale access branded as “open access” needs to be effective.⁶⁷ In the context of regulated open access, most of the concerns arise when an obligation for incumbent operators is not actually fulfilled, or it is not effectively enforced. Deficient quality of service, delays in the provision of wholesale products or discrimination against non-affiliated retail providers have often been alleged as being the reason why open access policies have not performed efficiently in some OECD countries. Countries that took the decision to implement functional or structural separation of the incumbent operator did so based on concerns about the actual enforcement of regulatory wholesale access obligations, known as “sabotage” in the economic literature. In conclusion, wholesale access has to be effectively provided if it is to be designated as open access.

Transparency

Transparency is another key feature of open access. The terms for any open access arrangement have to be transparent. If not publicly available, sufficient information about the terms of any open access arrangement must be made available to any interested parties, so that any access seeker may be aware of access terms and conditions.

Transparency may be implemented by means of a reference offer or by another mechanism that provides enough information to requesting parties. Transparency, where referring to NGA networks, may also be required for migration/transition plans from legacy networks to new fibre networks. The party leasing the copper has to make its migration plans public and advertise within a given delay that it intends to decommission its copper network.

Non-discrimination

Any open access arrangement has to be non-discriminatory. That is the reason why purely commercial negotiations, which do not apply the same access conditions to all interested players or, at least, do not have clearly established policies as to which conditions apply depending on potential access seekers, may not be classified as open access agreements. Non-discriminatory conditions should be considered as an integral part of every arrangement termed as “open access”.

Clearly, non-discrimination may not be achieved solely relying upon the non-discriminatory behaviour of the incumbent operators. In the context of regulated wholesale access, where incumbent operator(s) have the incentive to discriminate against alternative operators, a whole set of enforcement, monitoring and control measures have been set by regulators.

An alternative to imposing fair and reasonable access conditions on the parties offering access is ensuring that the incentives for discrimination are not present. That is generally the case for IXPs, which, as noted above, are usually operated by non-for-profit organisations unrelated to any of the access seekers nor to the incumbent operators, with some exceptions.

Fairness/reasonableness and price control obligations

Finally, any non-discriminatory, transparent and effective wholesale access must have some degree of fairness and reasonableness. For example, fair and reasonable requests for access should be given due course. Typically, disputes over the fairness of requests relate to the prices charged or the requested and offered technical characteristics of access requests. Even though there is no widespread agreement about the implication of fairness/reasonableness, these terms frequently appear in the context of regulated wholesale access.⁶⁸ In this regard, debates about fair access can hardly be separated from the discussion of price control obligations. In fact, price control obligations in whatever form they may take - price caps, retail-minus, cost orientation - are pivotal to guaranteeing one of the properties that open access should comply with – that of “effectiveness”.

As a necessary means to ensure effective open access, virtually every form of mandated open access entails some price-related obligations. As the resulting regulated price level is often subject to cost-orientation principles, gathering evidence about the costs incurred by the wholesale service providers is necessary. This usually involves a large degree of subject-matter knowledge and methodological challenges related to cost-accounting methodology, the willingness of operators to disclose accounting data and the cost-accounting models used to allocate costs. This work is usually undertaken by telecommunication regulators in most OECD countries and requires specialised staff and significant work in co-operation with operators.

Mandated vs. voluntary open access and private vs. public initiative

Voluntary open access in the context of access and backhaul networks remains relatively rare. Moreover, most of these cases are linked to the public ownership of the party offering open access, who aims at fulfilling public service obligation and public policy objectives. Purely private open access initiatives remain rare although some, wholesale-only proposed models, could be considered open access depending on the final conditions offered to requesting operators. They are, however, more likely to be classified as purely commercial agreements

The same considerations may well be derived for backbone infrastructure, including undersea cables. There may be little incentive to allow for open access when the infrastructure has been deployed by private market players, especially if they are backed by monopoly power in interconnecting networks. Most, if not all, of the initiatives which entail open access to undersea cables are consequences of the dominant position

of telecommunication operators running these cables, and thus a result of the lack of openness in accessing these infrastructures. That is the reason that public or semi-public initiatives were launched with open access policies in some regions.

Perhaps IXPs are one of the few exceptions to this pattern, in that they offer effective, transparent and non-discriminatory conditions for new members to adhere. It could be argued that IXPs are not purely private players, as most of them are non-for-profit organisations or are in a small number of cases associated with public authorities. It can also be argued that they do not provide open access, as they only provide interconnection among peers. On the other hand, it could be contended that an IXP is an infrastructure that any interested player may access on an open basis, and therefore it fully falls under the concept of open access.

Wired vs. wireless

Traditionally, the open access debate only concerned fixed networks. These networks suffered from economic bottlenecks, such as access to the local loop, which made the case for open access policies, in the form of regulated access, extremely compelling.

With the advent of mobile networks and, more markedly, after the increasing spectrum needs for wireless broadband networks, wireless networks have also been confronted with an economic bottleneck: limited spectrum resources. Lower costs of deployment for mobile networks may render wholesale-only models more feasible than they have been for fixed networks, although there is little evidence to date of wholesale-only mobile operators enjoying commercial success. Infrastructure sharing agreements appear to be gaining importance and this may be the trend in many countries for the deployment of LTE networks.

The role of open access in developing competition dynamics

The importance of open access policies, mostly in the form of regulated access should not be underestimated. The role of local loop unbundling in developing competition in numerous OECD countries has been significant. Success stories such as France or the United Kingdom in Europe or Japan and Korea in Asia are partly, if not mostly, the outcome of well implemented open access policies. While the debate over levels of investment, innovation, competition and so forth is an on-going one it is likely to become even more critical as NGAs are further developed.

The role of open access policies for undersea cables, publicly funded broadband networks and backbone networks also has to be recognised. Market failure has often been tackled through open access policies, usually in the form of mandated open access or private-public partnerships for investing in facilities where private initiative has not been found to be in line with public policy objectives.

Harmonising open access regimes

One of the challenges in dealing with open access policies from many different perspectives is the possible inconsistencies in implementation, regulatory uncertainty or incoherent obligations imposed by different regimes which may create methodological and/or practical differences in implementing open access policies or may even result in inconsistent obligations for telecommunication providers.

In this respect, formal and informal co-operation between the different authorities, *e.g.* competition authorities, telecommunication regulators, public funding agencies, should be strengthened. As *ex-ante* regulatory authorities usually have well-developed subject-matter expertise on wholesale regulation, cost-accounting methodologies and implementation/enforcement issues surrounding open access policies, these authorities should be involved by means of consultation in the process of laying down the conditions attached to open access broadband networks.

If a public authority grants some funds for the deployment of an open access broadband network, it would be highly advisable that it gathers advice from the telecommunication regulator and ensures that open access conditions are coherent with existing or future *ex-ante* obligations for this area or, at a minimum, some rationale is provided on the relationship between both sets of measures.

With respect to the coherence of open access conditions imposed by competition authorities, again they should observe the approach taken by national regulatory authorities and, if these measures are to be qualified as complementary - either by jurisdictional issues or by new findings - they should acknowledge and provide the rationale for such measures to be taken.

If enforcement measures relating to open access networks are not directly overseen by the regulatory authority, some co-operation mechanism must be implemented in order to guarantee that this implementation benefits from the subject-matter knowledge that the national regulatory authority has in dealing with mandated regulated access.

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ENDNOTES

- ¹ Bourreau, M and Dogan, P. (2006) provides a model on why and how entrants make choices on infrastructure deployment depending on the regulated LLU price.
- ² Cave (2006) proposed a model by which new entrants face increasing investment level (“the rungs of the ladder”) when trying to replicate the incumbent’s infrastructure. The higher the investment, the more independently they can provide the service and innovate.
- ³ BEREC has recently published a report on the regulation of co-investments in NGA networks, berec.europa.eu/files/document_register/2012/8/bor_12_41.pdf.
- ⁴ ISO/TC97/SC16, “Reference model of open systems interconnections”, Doc. N227, June 1979.
- ⁵ erg.eu.int/doc/berec/bor_11_05.pdf
- ⁶ Public Notice CRTC 2006-96
- ⁷ See for example, *United States Telecom Ass’n v. FCC*, 359 F.3d 554 (D.C. Cir. 2004), available at transition.fcc.gov/ogc/documents/opinions/2004/00-1012-030204.pdf
- ⁸ *National Cable & Telecomm Ass’n v. Brand X Internet*, 545 U.S. 967 (2005).
- ⁹ *Appropriate Framework for Broadband Access to the Internet over Wireline Facilities*, Report and Order and Notice of Proposed Rulemaking, CC Docket No. 02-33, 20 FCC Rcd 14853 (2005), available at fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-05-150A1.doc
- ¹⁰ See mpira.ub.uni-muenchen.de/2455/1/MPRA_paper_2455.pdf
- ¹¹ See generally *In re Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers et al.*, Report and Order and Order on Remand and Further Notice of Proposed Rulemaking, 18 FCC Rcd 16978, 16984, para. 3 (2003), available at hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-36A1.doc
- ¹² The Committee to set and update “Bezeq” tariffs, and to set tariffs for wholesale services in fixed communications. www.moc.gov.il/sip_storage/FILES/8/2528.pdf
- ¹³ Announcement of Launch And Invitation to Participate in the Election Process for the Election of a Controlling Shareholder, Investor And Co-Founder of the Telecommunications Company to be Jointly Established by the Elected Controlling Shareholder and Israel Electric Corporation Ltd, www.iec.co.il/EN/CommunicationProject/Documents/PreAnnouncement.pdf
- ¹⁴ Recent regulatory reform in telecommunications. Presentation at the OECD by the Japanese government. 24 April 2008, unpan1.un.org/intradoc/groups/public/documents/apcity/unpan045893.pdf, and presentation at the 45th CISP Working Party meeting (OECD), in June 2011.
- ¹⁵ OECD Broadband Portal, www.oecd.org/sti/ict/broadband

16 Middleton, C. A. and Chang, S. (2008), “The Adoption of Broadband Internet in Australia and Canada”, Handbook of Research on Global Diffusion of Broadband Data Transmission, pages 820-842, www.broadbandresearch.ca/ourresearch/middleton_chang_preprint.pdf (preprint)

17 For example, those included in the document “Costing methodologies and incentives to invest in fibre”, prepared by Charles River Associates for the DG Information Society and Media of the European Commission, ec.europa.eu/information_society/policy/ecom/comm/doc/library/ext_studies/20120705_finalreport_costing_cra.pdf

18 Art. 12 of the Framework Directive (as per Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009).

19 www.comlaw.gov.au/Details/C2011A00022, <http://www.nbnco.com.au>

20 www.nbnco.com.au/getting-connected/service-providers/wholesale-broadband-agreement.html

21 www.crownfibre.govt.nz/crown-partners/retail-service-providers/

22 www.nbr.co.nz/article/consumer-groups-combine-forces-criticise-new-telco-law-joyce-unmoved

23 www.crownfibre.govt.nz/2011/05/regulatory-forgiveness-to-be-replaced/

24 See Article 13a of Directive 2002/19/EC as amended by Directive 2009/140/EC.

25 PPPs are contractual agreements adopted in a variety of fields between a public and a private sector entity whereby the private party agrees to design, build and manage an asset (often an infrastructure asset) and to bear some of the risk associated to these activities. PPPs may thus take many different forms, associated to different degrees of involvement of public players. Some may have the form of DBO (Design-Build-Operate), BT (Build and Transfer), BOT (Build-Operate and Transfer), BRT (Build-Rent and Transfer) (Parcu et al., 2011)

26 www.stokab.se

27 www.malarenergi.se/en/sub/products/broadband

28 www.malarenergi.se/en/sub/products/broadband

29 www.xarxaoberta.cat/

30 www.blizznet.at

31 www.feei.at/img/db/docs/3219.pdf

32 www.covage.com/, www.axia.com/

33 *Applications for Consent to the Transfer of Control of Licenses and Section 214 Authorizations by Time Warner Inc. and America Online, Inc., Transferors, to AOL Time Warner Inc., Transferee*, Memorandum Opinion and Order, CS Docket No. 00-30, 16 FCC Rcd 6547 (2001), available at transition.fcc.gov/Bureaus/Cable/Orders/2001/fcc01012.doc

34 hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-11-103A1.pdf

35 Many MVNOs do not publicly report subscriber data and it is a standard practice to include MVNO subscribers with the subscribers of the host facilities-based providers. During the second quarter of 2011, for instance, Verizon added 896 000 wholesale customers (out 1.4 million total net adds), and around 460 000 of those came from Straight Talk, one of TracFone's brands, www.fiercewireless.com/special-reports/whats-next-nations-roughly-four-dozen-mvno.

36 www.totaltele.com/view.aspx?ID=472783

37 Directive 2002/19/EC, of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities (Access Directive).

38 *Avis n° 08-A-16 du 30 juillet 2008 relatif à la situation des opérateurs de réseaux mobiles virtuels (MVNO) sur le marché français de la téléphonie mobile*, www.autoritedelaconcurrence.fr/pdf/avis/08a16.pdf

ARCEP has included a number of MVNO-related criteria under the 4th 3G license tendering process, responding to the competition concerns in this market.

39 www.soumu.go.jp/menu_news/s-news/01kiban14_02000079.html

40 In order to identify markets that are susceptible to *ex ante* regulation, it is appropriate to apply the following cumulative criteria. The first criterion is the presence of high and non-transitory barriers to entry. These may be of a structural, legal or regulatory nature. However, given the dynamic character and functioning of electronic communications markets, possibilities to overcome barriers to entry within the relevant time horizon should also be taken into consideration when carrying out a prospective analysis to identify the relevant markets for possible *ex ante* regulation. Therefore the second criterion admits only those markets whose structure does not tend towards effective competition within the relevant time horizon. The application of this criterion involves examining the state of competition behind the barriers to entry. The third criterion is that application of competition law alone would not adequately address the market failure(s) concerned.

“Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services” (Second edition).

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42 www.soumu.go.jp/menu_news/s-news/02kiban03_000027.html

43 “Open Network Access” for Third Generation (3G) Mobile Services, 29 May 2001, Office of the Telecommunication Authority, Hong Kong, China.

44 transition.fcc.gov/Daily_Releases/Daily_Business/2012/db0215/DA-12-214A1.pdf

45 www.americantower.com/atcweb

46 www.gtlinfra.com/

47 www.rtr.at/en/tk/TKKPosition2011/Position_Paper_TKK_Infrastructure_Sharing.pdf

48 en.itst.dk/telecom-internet-regulation/masts/Act%20on%20the%20Establishment%20and%20Joint%20Utilization%20of%20Masts%20for%20Radiocommunications%20Purposes%20etc.%20%28Mast%20Act%29.pdf

49 stakeholders.ofcom.org.uk/binaries/consultations/msa/summary/msa.pdf

50 hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-08-260A1.pdf

51 www.telecompaper.com/news/yota-to-build-wholesale-lte-network-for-russian-operators

52 www.balancingact-africa.com/news/en/issue-no-571/money/kenya-s-government-g/en

53 www.oecd.org/dataoecd/7/38/49536828.pdf

54 EURO-IX - Euro-IX has accepted the industry definition of an IXP as: “A physical network infrastructure operated by a single entity with the purpose to facilitate the exchange of Internet traffic between Autonomous Systems. The number of Autonomous Systems connected should at least be three and there must be a clear and open policy for others to join.”

55 www.ausnog.net/files/ausnog-03/presentations/ausnog03-moyle-croft-peering.pdf,
www.pipenetworks.com/docs/mlpa.pdf

56 www.tespok.co.ke/index.php/kixp

57 www.cabase.org.ar/backend/upload/File/igf-ixp-report-2007.pdf

58 neutrinx.com/page/

59 www.nwax.net/default.asp

60 www.circleid.com/posts/20120510_ixps_cdns_critical_to_the_future_of_competitive_broadband_internet/

61 www.eclac.cl/socinfo/noticias/noticias/2/45942/120224_CEPAL_CONATEL_BA_General_v2.pptx

62 unasur.org/PDFs/Declaraciones/II-Reunion-Comunicaciones-Hoja-de-Ruta.pdf

63 www.eassy.org/

64 www.wiocc.net

65 www.arcep.fr/uploads/tx_gspublication/rapport-dom-080110.pdf

66 www.gob.cl/informa/2012/05/07/subtel-presenta-radiografia-de-telecomunicaciones-penetracion-de-internet-uso-de-smartphones-y-recor.htm

67 Oxford dictionary, oxforddictionaries.com/definition/effective?q=effective: *adjective* successful in producing a desired or intended result: *effective solutions to environmental problems* (of a law, rule, or policy) operative: *the regulation will be **effective from** January*.

68 For example, in the context of the symmetrical obligation laid down by the French regulatory ARCEP, there is a requirement for the building operator to allow other operators to provide ultra-fast broadband services to the residents under fair and non-discriminatory conditions.

Stokab, a socio-economic analysis

Summary

Stockholm, 30 May 2013

16 billion SEK in socio-economic return

For almost 20 years, the City of Stockholm, via Stokab, has strategically invested in the development of an open, operator-neutral fibre network for everyone. Many articles and reports have been written on this, but primarily from a journalistic perspective. However, no research studies were until now available on the economic effects which Stokab generates for Stockholm. Acreo Swedish ICT has therefore carried out a study. The study shows that these investments have achieved the desired effects on the city's IT development and the establishment of IT-related activities, but also that they have generated significant economic benefits for society, enterprises and citizens.

The final report "*Stokab, a socio-economic analysis*" describes the Stokab model and its effects on the different stakeholders, analysing Stokab's own economy, cost savings for the municipality and the county administration, as well as benefits for businesses and end users. Moreover, Stockholm is compared to Copenhagen, which has conditions similar to Stockholm, but where the municipality has not taken an active role in the city's fibre network.

The socio-economic return on Stokab investment in fibre infrastructure is estimated in this study to over 16 billion SEK, or €1.9 billion at the current exchange rate. This result is based on a few quantifiable effects alone and we expect the actual return to be considerably larger.

Acreo Swedish ICT and study methodology

Acreo Swedish ICT is a research company that develops competence in electronics, optics and communication technology and has as a goal to turn research into commercially viable products and processes. Acreo is owned 60% by the Swedish government and 40% by the Swedish industry (hardware and software companies).

Acreo conducts several scientific socio-economic studies regarding fibre and broadband. One example is a study on the socio-economic impact of FTTH carried out on behalf of the Swedish government's Broadband Forum (*Bredbandsforum*). The study focuses particularly on fibre deployment impact on employment, the value of fibre for the individuals as well as the cost-savings made possible thanks to fibre. Recently, the European Commission has commissioned from Acreo a review of the Commission's *Guide for Broadband Investment*.

The Stokab model

Stokab owns and is responsible for the passive fibre network, while market players operate and deliver services over the network. Stockholm city's basic idea is that IT infrastructure should be available to the whole society, public sector, telecom operators, and other businesses alike. Therefore Stokab's network is designed to facilitate competition and the fibre network is open to everyone on equal terms.

The aim of the network deployment is to create an ICT infrastructure that allows competition by giving telecom operators and other companies and organisations access to the infrastructure. This vision differs from the prevailing opinion in the rest of Europe where fibre and broadband networks are often considered as a network for telecom operators. Stokab, however, has now inspired several municipal and regional fibre networks throughout Europe and the world, and the open network model is becoming increasingly appreciated. Stockholm is often cited as an IT world-class city.

Besides passive fibre lines, Stokab provides physical space in nodes equipped with power, cooling, etc. Stokab's fibre network connects almost all multi-dwelling units and commercial properties in the Stockholm municipality: about 90% of households and almost 100% of enterprises have the possibility to sign up for a fibre-based connection.

An extensive backbone network connects industrial areas, all major healthcare facilities and urban centres in the region. The fibre network is available in all parts of the municipality and as an extensive interconnecting network in the region. With its 1.25 million kilometres of fibre, Stockholm is one of the world's most fibre developed cities.

Since the company's inception in 1994, the passive network structure and the business model have been designed to enable all stakeholders to define their own network structure. The lease of the network can expand as well as shrink based on a player's need.

In 2012, Stokab had over 100 telecom operators and more than 700 companies/organisations as customers. These can directly lease fibre from Stokab to deliver services in competition, without the services being related to the infrastructure. Virtually all telecom operators in Sweden have facilities in Stokab network nodes. National and international fibre connections reach Stokab nodes so that all operators can gain access to links throughout Sweden and the rest of the world, through virtually any operator.

Stockholm, an IT-city

It is no exaggeration to state that Stokab had great importance for Stockholm's businesses and IT-development. Without Stokab's fibre network, science parks like Kista, north of town, would probably not have developed into what today's success: Kista Science City, for instance, has more than 1,000 ICT companies and around 24,000 employees, as well as 6,800 university students and 1,100 researchers within ICT. It is an attractive environment for ICT companies and developers so it is not surprising that all major IT and telecom companies have offices in Kista, as well as universities and research institutes like Swedish ICT.

The fibre network has also facilitated innovations and new enterprises such as Spotify, Klarna and Skype. Media companies have also been able to produce television in a whole new way.

Profit enables investments

For the past 20 years, Stokab has invested an average of more than 250 million SEK per year, to total **5.4 billion SEK** up to 2012. This investment has been possible thanks to the profits generated by Stokab. The accumulated profit reached break-even in 2001 and has now passed

1 billion SEK. The profit has until now been low compared with the investments, due to the heavy upfront investments required in the initial phase. From the year 2005, however, returns have increased steadily which has enabled further major investments. It is worth mentioning that the fibre network was built without tax funds and was instead financed via revenues and loans.

A neutral fibre infrastructure stimulates the market

Through an extensive open fibre network provided by a neutral player, telecom operators can lease and design their own fibre networks without having to make costly investments or leasing from a competitor. Today, to lease fibre in Stockholm costs less than half (sometimes much less) than in other capitals around the world. This translates into lower costs not only for operators but also for all enterprises that have a need for fast and reliable communications. Lower prices also propagate down the value chain and stimulate new services and entrepreneurship.

The fibre network also delivers a wide range of indirect effects on society. It enables, for example, the use of cloud services, videoconferencing, healthcare, distance education, and other bandwidth-hungry services like HD-TV, video on demand and other streaming media. Moreover, innovation power is unleashed when both small businesses and households have the same access to broadband connectivity which previously was only available to large companies.

Lower broadband prices to enterprises

Since telecom operators compete on equal terms, competition is fierce in Stockholm, which leads to lower prices for broadband, compared to cities where competition is weaker. Savings due to lower broadband costs for companies are estimated to approximately **75 million SEK per year** if compared to Copenhagen. The difference becomes even more significant when other European cities are used as benchmark.

The role of housing companies in broadband development

Stockholm city's housing companies have had a major role in the development of broadband. Early on they adopted a broadband policy to connect their properties to Stokab's network and to install fibre all the way to each apartment. They are also installing home networks inside the apartments with outlets in every room. Through collaboration models, they have inspired other property owners of multi-dwelling units to join Stokab's network. The housing companies' accumulated investment now amounts to **nearly 2 billion SEK**.

Building a property network has also other merits beyond the mere delivery of broadband services to the tenants. Since the property owners connect all parts of the property, the communications network can even be used for managing, monitoring and measuring the facilities.

Increased property value

By connecting multi-dwelling units with fibre, property owners have been able to more effectively use the control and automation services, electronic locks, surveillance etc, while at the same time being able to raise the rent as the fibre connection has given tenants an added value. Until now, fibre connectivity has led to a use value for the tenants and a higher property value for municipal housing companies in Stockholm (nearly 100,000 apartments) of **1.85 billion SEK**, as well as increased rental revenues of over **30 million SEK per year**. These effects cover the housing companies' investments almost in full and are expected to grow in the coming years.

4G/LTE deployment

Generally, when building a 4G/LTE network, 70-80% of the total cost derives from deployment of fibre infrastructure. In principle, each base station needs to be fibre connected to sustain the high 4G/LTE capacity. Leasing the needed fibre connections instead of investing in an own backhaul network can significantly reduce the deployment cost for 4G/LTE. The world's first 4G/LTE network was installed in Stockholm. Net4Mobility (jointly owned by operators Telenor and Tele2) states that 4G/LTE would have never been launched in Stockholm if the necessary fibre

had not been available to lease from Stokab. Today, four extensive 4G/LTE-networks are present in Stockholm.

Savings for Stockholm's local governments

Since Stockholm City and Stockholm County have been able to connect their premises with fibre, it has become possible to purchase data and telecommunications services on an open market. This has generated a cost saving for the municipality and for the county of **about 2 billion SEK** in the years 1996 – 2012.

Supplier industry activity

Stokab procures the deployment, operation, materials, planning, etc. from the private market. The procurement process and the large investments made over the years have generated an economic activity that is estimated to **over 5 billion SEK** in the supplier industry.

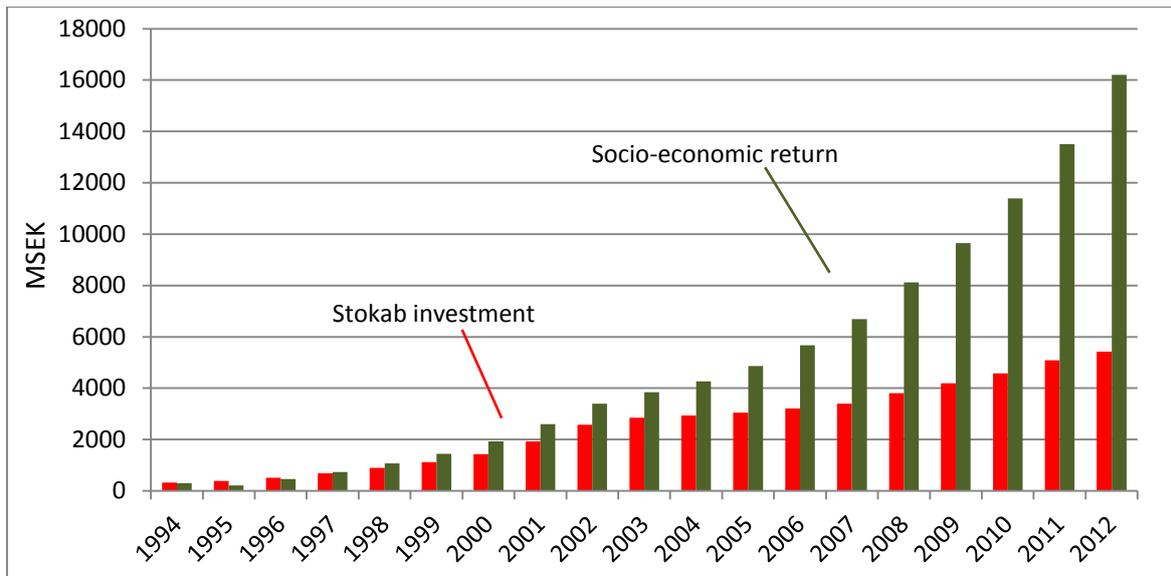
Employment

Several studies show that high-capacity broadband leads to growth and jobs creation (beyond the above-mentioned short-term economic activity generated in the supplier industry), e.g. through the development and use of advanced services and products, as well as higher ICT competence, which in turn leads to increased productivity and entrepreneurship. According to Acreo's econometric model, the "job value" which the fibre network has created in Stockholm is estimated at about **7.7 billion SEK**.

Returns three times greater than investments

Based on the effects discussed in the study, the benefits of Stokab sum up to nearly three times the investment. Since only a few factors have been calculated, the total return on the investment is likely to be considerably larger.

The figure on next page shows, in million SEK, the accumulated investments (red) and the socio-economic return (green) calculated as the sum of: increased property value and revenues for the municipal housing companies, added value for their tenants, increased employment, Stokab's return, saving for local governments' ICT costs, as well as the increased economic activity in the supplier industry.



Stockholm vs. Copenhagen

Stockholm and Copenhagen are relatively similar in terms of size, population and economy. It is particularly interesting to compare the broadband situation in the two cities, since diametrically opposite conclusions were reached in connection with the deregulation of the telecom market, as to who should own the ICT infrastructure and how this should be organised.

Stockholm chose, as already described, to view the ICT infrastructure as something that should be accessible to everyone and be delivered by a neutral player in order to create competition. Copenhagen opted, like most of Europe, to see the ICT infrastructure as the direct prerogative of the market and telecom operators. This has resulted in the incumbent player TDC being the one who owns and controls most of the ICT infrastructure in Copenhagen.

After about 20 years, it is interesting to see what differentiates the two cities. Regarding the development of the fibre network, barely 20% of multi-dwelling units in Copenhagen are connected, to be compared with more than 90% in Stockholm. This means that in Stockholm there are considerably more people that can get high speed broadband, and the cost for a broadband provider to reach customers is lower because the passive infrastructure (representing around 80% of total investment) is already there. Even the price of dark fibre, the basic ICT infrastructure, is significantly lower in Stockholm than in Copenhagen for both consumers and enterprises.

While in Stockholm all those who need fibre can design their network structure themselves, in Copenhagen the design possibility is heavily limited because the dominant player chose to build a the network frugally, and designed to meet their own service-delivery needs. The result is a fibre-poor network, which decreases flexibility and design possibility drastically for other operators.

The low level of fibre deployment in Copenhagen also affects the possibility of symmetric high-speed broadband connection. Hence, while broadband at 100 Mb/s speed both downstream and upstream is common for the majority of residents in Stockholm, it is virtually impossible for households in Copenhagen. Moreover, the price of an asymmetric broadband connection (with low upstream speed) in Copenhagen is almost twice the price of a symmetric broadband connection (with high upstream) speed in Stockholm.

This has also a strong impact on the business climate, as the possibilities for data communication are crucial for the business creation. It is symptomatic for instance, that more and more international enterprises have chosen to locate their Scandinavian headquarters in Stockholm: in 2009, Stockholm had 69% more establishments than Copenhagen (compared to 10% in 2006).

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INSTITUTE OF CALIFORNIA

Does Broadband Boost Local Economic Development?

January 2010

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Summary

“Broadband” refers to high-speed Internet service that—unlike dial-up modem service—is always “on.” This technology has become widely available throughout the United States. It is essential for businesses, and well over half of American households have broadband access at home.

In recognition of its importance, public investment in broadband is surging. The American Recovery and Reinvestment Act (ARRA) of 2009 allocated \$7.2 billion for broadband investment and commissioned a National Broadband Plan to promote universal access, foster economic development, and achieve additional potential benefits through this technology. Several California programs also support the expansion of broadband access, especially in areas where availability is lagging.

This report assesses whether policies to raise broadband availability will contribute, as hoped, to local economic development. Our analysis relies on the fact that broadband technology has diffused unevenly throughout the United States, thus allowing us to compare economic indicators between areas with greater and less growth in broadband availability. Using broadband data from the Federal Communications Commission and economic data from several government and proprietary sources, we examine broadband availability and economic activity throughout the nation between 1999 and 2006.

Our analysis indicates a positive relationship between broadband expansion and economic growth. This relationship is stronger in industries that rely more on information technology and in areas with lower population densities. Although the evidence leans in the direction of a causal relationship, the data and methods do not definitively indicate that broadband caused this economic growth.

The economic benefits to residents appear to be limited. Our analysis indicates that broadband expansion is also associated with population growth and that both the average wage and the employment rate—the share of working-age adults that is employed—are unaffected by broadband expansion. The economic benefits to households are thus more ambiguous than they would be if employment growth also led to an increase in wages or the employment rate. We also found that expanding broadband availability does not change the prevalence of telecommuting or other home-based work. Of course, local employment growth might still raise property values and the local tax base, but in the absence of more direct benefits for residents in the form of higher wages or improved access to jobs, we can only say that the local economic development benefits of broadband are mixed.

Broadband expansion may of course offer other social or economic benefits, such as improved health care delivery. Although our study does not examine such effects, we briefly review the limited evidence of other benefits in the conclusion of the report.

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Introduction

Since the mid-1990s, when businesses and households began to use the Internet, observers have been trying to predict—and more recently to assess—the effects of this relatively new mode of communication. Some of the early predictions about the Internet and related technologies, such as causing the “death of cities,” have clearly not materialized.¹ But we still know very little about the economic effects of these technologies.

The Internet has transformed many areas of life, providing individuals and businesses with easy and instant access to communication, information, and entertainment. But it may take years before the Internet—like many other new technologies—exerts a quantifiable effect on business productivity. It takes considerable time to develop applications and adjust business processes and organizations to take full advantage of new technologies.²

Nonetheless, governments need to assess whether new technologies are likely to offer benefits in the public interest and whether the private sector will make the technology available and affordable enough to support public policy goals. Occasionally, governments will deem a new technology essential for achieving these goals and will support universal access, even in areas that are expensive to serve.

The federal government and the state of California, as well as other state and local governments, have made universal access to broadband service a public policy goal—the specific objective is to close the digital divide in broadband availability.³ The phrase “digital divide” can refer to geographic inequalities in availability or to gaps in broadband adoption owing to income, race/ethnicity, education, or other inequalities in access or skills that affect the ability of individuals or businesses to take advantage of broadband’s capabilities.⁴ To help promote the goal of universal access, the federal government allocated \$7.2 billion for broadband investment and also commissioned a National Broadband Plan as part of its 2009 American Recovery and Reinvestment Act (ARRA). These federal “stimulus” funds provided a large addition to existing state and local efforts to support broadband access.

The federal and state broadband initiatives presume multiple economic and social benefits will accrue from increasing broadband access. Local economic development ranks high among these benefits. Other benefits include improvements in health care delivery, access to education, energy efficiency, civic participation, and public safety. To date, the evidence on the extent to which broadband provides any of these benefits has been quite limited.

In this report, we are particularly interested in the relationship between broadband and economic development. Previous research has not assessed whether broadband expansion causes economic development, nor has it examined who benefits from increased economic activity; there has been little research on the effect of broadband on outcomes other than employment, output, and income. Our analysis relies on the fact that broadband technology has diffused unevenly throughout the United States, thus enabling us to compare economic indicators between areas with greater and less growth in broadband availability. In this report, we examine broadband availability throughout the nation between 1999 and 2006. Our parameters are partly determined by our

¹ George Gilder, *Forbes ASAP*, February 27, 1995. Quoted in Mitchell Moss, “Technology and Cities,” *Cityscape* 3:3.

² “The Broadband Myth,” *The Economist*, May 23, 2008.

³ While broadband can include satellite and high-speed mobile data services, the vast majority of households and businesses that subscribe to broadband receive their service over cable, digital subscriber line (DSL), or other technologies that use physical wires or cables to connect end-users to the Internet. Discussions about broadband availability usually refer to wireline technologies.

⁴ “Digital divide” can refer to inequalities in the availability or adoption of other technologies as well. See Gunkel (2003).

data: Federal Communications Commission (FCC) data on broadband are available beginning in 1999, and our source for detailed employment data ends in 2006. We answer four questions:

1. Does employment grow faster in areas with greater broadband expansion?
2. Does the relationship between broadband and employment differ by industry or across places? For example, is it stronger for industries that are more reliant on technology or that use workers who are more technically knowledgeable? Is it stronger in places that are more isolated or in those with more amenities?
3. If there is a positive relationship between broadband and employment growth? Does broadband expansion *cause* employment growth?
4. If broadband does boost employment, who benefits? Is employment growth accompanied by a greater likelihood of employment, higher pay, increased income, or greater flexibility to be able to work from home?

Although other studies have examined broadband and economic growth, this report offers more definitive answers by using richer data and more-refined methods. We also examine questions left unanswered in previous work, such as whether broadband actually *causes* economic growth, who benefits from this growth, and whether broadband increases telecommuting and other forms of home-based work. Of course, economic development is only one of many policy concerns that must be considered when targeting broadband investments, and in our concluding chapter we briefly review the limited evidence available on other potential benefits of this technology, including improved health care delivery and overall consumer welfare.

We begin our discussion in the next chapter with a description of the national and California policies designed to increase broadband availability. We then describe the extent of broadband availability, explain why some places have better broadband access than others, and discuss the limitations of the available data. We then present our research questions, the methods we use to answer them, and the main findings of our study. We conclude with a discussion of the policy implications of our findings and then briefly review other possible effects of broadband that are outside the scope of our analysis. A [technical appendix](#) offers further details about related research and our data, methods, and results.

Broadband Policies and Goals

Broadband policy at both the national level and in California is designed to achieve multiple goals, most prominently economic development. The federal government, through Congress, the executive branch, and the Supreme Court, has shaped broadband policy through important regulatory decisions.⁵ And today, federal public investment in broadband is surging. ARRA, the \$787 billion economic stimulus package passed in 2009, allocated \$7.2 billion to broadband investments, with a particular focus on increasing broadband availability in targeted areas to improve economic development.⁶ ARRA also requires the development of a National Broadband Plan to guide broadband policy beyond the federal stimulus funds. This plan is supposed to be wide-ranging, covering numerous technologies, policy options, and goals.

Well before the current federal investment in broadband, state and local governments have subsidized and in some cases directly provided broadband services. California has several programs in place that subsidize the demand and supply of broadband. The stated goals of these policies—described in detail below—include job creation and economic growth, civic participation, public safety, education, health care, and access to government services. Like federal policies, some California initiatives are more narrowly targeted toward underserved areas and economic development goals, while other programs are focused on a wider set of concerns, such as health care and education.

In sum, broadband policy at the federal level and in California aims to achieve a wide range of goals, with a particular emphasis—especially in the federal broadband stimulus—on raising broadband availability in unserved and underserved communities in an effort to create jobs and stimulate economic growth.

The Federal Economic Stimulus and the National Broadband Plan

Signed into law in February 2009, ARRA directs two federal agencies, the Department of Agriculture’s Rural Utilities Service (RUS) and the Department of Commerce’s National Telecommunications and Infrastructure Administration (NTIA), to grant or lend \$7.2 billion for broadband deployment and other broadband projects.⁷

ARRA directs both agencies to consider the effect on economic development when awarding funds. RUS will offer grants, loans, and loan guarantees worth \$2.5 billion for broadband infrastructure projects in rural areas that lack “sufficient access to high speed broadband service to facilitate rural economic development.”⁸ NTIA will award grants worth \$4.7 billion to states, non-profits, and broadband providers for a wider set of broadband projects—not just infrastructure projects and not just in rural areas. While economic growth and job creation are explicit goals of NTIA’s funds, as is raising broadband access in unserved and underserved areas, so is improved broadband access for schools, medical facilities, other community institutions, and

⁵ The 1996 Telecommunications Act, the 2005 Supreme Court decision in *National Cable & Telecommunications Association et al. v. Brand X Internet Services et al.*, and related FCC rulings helped create the national regulatory framework in effect today. Under this framework, telephone, wireless, television, and Internet providers are able to compete in any market against each other, but broadband providers are not required to give competitors wholesale access to their infrastructures that would enable competitors to resell services to consumers.

⁶ Of the \$4 billion to be allocated in the first round of funding, 75 percent has been targeted toward infrastructure projects.

⁷ Applications for broadband stimulus funds are being accepted and reviewed in multiple rounds. First round applications were due in August 2009; up to \$2.4 billion of the RUS funds and \$1.6 billion of NTIA funds will be awarded in this round. Subsequent rounds will award the remainder of the \$7.2 billion by September 2010. Stimulus funds will be allocated by RUS through the Broadband Initiatives Program (BIP) and by NTIA through the Broadband Technology Opportunities Program (BTOP).

⁸ ARRA, (H.R. 1) Title I, p. 4.

public safety agencies. Together, these two components illustrate the prominence of economic development and job creation as goals for the broadband stimulus funds, among other goals.

ARRA also requires the FCC, the national telecommunications regulator, to present a National Broadband Plan to Congress in February 2010 to guide future broadband policy. The Plan is supposed to “seek to ensure that all people of the United States have access to broadband capability” and is an acknowledgement that the broadband stimulus funds alone are “insufficient to support national broadband deployment.”⁹ The Plan should recommend goals and benchmarks for a national broadband strategy and for achieving eleven enumerated policy goals, including job creation and economic growth, entrepreneurial activity, and other specific targets such as consumer welfare, civic participation, public safety, education, and health care delivery.¹⁰ The plan will thus cover a wider range of interests and technologies than the broadband stimulus funds, which are geared toward infrastructure, technology mapping, and related activities.

Broadband Policy in California

Well before the passage of ARRA, states and localities—including the state of California and some of its cities and counties—have made broadband investments through subsidies and direct provision.¹¹ As with federal broadband initiatives, California’s broadband policy is focused on numerous goals, with economic development prominent among them.¹²

For many years, the state’s primary broadband subsidy program has been the Teleconnect Fund, established in 1996, which pays half the cost of Internet access for qualified schools, libraries, community organizations, and other nonprofits, funded through a statewide fee on telephone service. The program has grown from \$33 million in FY 2008–2009 to \$47 million (proposed) in FY 2009–2010 and \$67 million (proposed) in FY 2010–2011.¹³

Two newer programs have expanded the state’s involvement in broadband infrastructure deployment. In 2006, the California Public Utilities Commission (CPUC) created the California Emerging Technology Fund (CETF), an independent nonprofit foundation. CETF has received funding for its first five years through a \$60 million contribution from AT&T and Verizon, a condition of their respective mergers with telecommunications companies SBC and MCI. CETF’s mission is to achieve “ubiquitous access to broadband and advanced services in California, particularly in underserved communities.” The foundation seeks to promote broadband availability in rural areas, affordability and adoption in urban poor and other disadvantaged areas, and accessible technology for people with disabilities. CETF hopes to disburse \$240 million over five years, supplementing its own seed money with matching funds. As of December 2008, it had awarded \$20 million in grants. The largest award helped support the California Telehealth Network (CTN), which electronically connects hundreds of clinics and hospitals—primarily in rural areas and tribal lands—to medical centers. CETF’s support also helped CTN win a larger grant from the FCC’s Rural Health Care Pilot Program.

⁹ ARRA (H.R. 1), Section 6001 (k)(2), p. 402; FCC Notice of Inquiry 09-31, 2009, paragraph 6.

¹⁰ The FCC’s Notice of Inquiry reviews these and other current FCC activities that relate to broadband.

¹¹ Although the major current initiatives are sponsored at the federal and state levels, some localities in recent years have provided broadband directly through public municipal Wi-Fi (wireless) networks, fiber-optic networks, or other broadband technologies. Kolko (2007) discusses local initiatives in California.

¹² In addition to the subsidy and investment programs described in this section, California has set broadband policies through the final report of the California Broadband Task Force, created by Executive Order S-23-06 in 2006, and the 2006 Digital Video and Infrastructure Competition Act (AB 2987), which created statewide video franchises and established the CPUC’s responsibility for collecting and mapping broadband data.

¹³ Actual and proposed budgets are available at the CTF website, www.cpubc.ca.gov/PUC/Telco/Public+Programs/CTF/CTFList.htm.

The second new state program is the California Advanced Services Fund (CASF), which is providing \$100 million over two years to subsidize broadband deployment in unserved and underserved areas; successful applicants are awarded 40 percent of total project costs for broadband infrastructure in these areas. CASF was authorized by the CPUC in 2007 and implemented in 2008 under SB 1193 (Padilla); the first projects were funded in November 2008. Whereas CETF has a broad strategy that includes infrastructure availability, adoption, applications, and technology literacy, CASF is more narrowly focused on promoting infrastructure availability in the largely rural parts of the state that lack adequate broadband. Thus, the main goal of CASF is quite similar to the objectives of the portion of the broadband stimulus funds targeted toward broadband availability in rural areas.

The funds currently available through state programs—the Teleconnect Fund, CETF, and CASF—are small relative to the sums California might expect to receive under the federal broadband stimulus program. While the state programs have budgets or plans to disburse tens of millions of dollars annually, California’s share of the federal broadband funds would be over \$900 million.¹⁴ Thus, an essential element in California’s current broadband strategy is to win federal broadband stimulus funds. Numerous cities, counties, nonprofits, and companies in California were among the first-round applicants for federal funds: Their grant and loan requests totaled \$1.4 billion.¹⁵ CPUC was a winner in the first round of the separate broadband mapping funds competition, receiving a \$2.3 million grant in October 2009.¹⁶

California’s expectations, like those of the federal government, are that broadband will contribute to economic development. The final report of the California Broadband Task Force, for example, lists “economic and community development” first among the ways that broadband is likely to affect California, citing the potential effect of broadband on job creation in high-tech and other industries as well as on employment in rural areas.¹⁷ The state also expects broadband to lead to increased telecommuting and environmental benefits. In establishing its definition for “underserved” areas for CASF grant eligibility, the CPUC chose the minimum speed that would support telecommuting.¹⁸ In turn, the California Air Resources Board cites telecommuting as one way the state government can encourage its own employees to “decrease their individual carbon impact.”¹⁹

¹⁴ CETF’s “Summary of ARRA Proposals” estimates California’s “fair share” to be 13 percent of the federal total, proportional to the state’s share of the national population.

¹⁵ These applications have been submitted for the first round of \$4 billion in federal funds, of which California’s 13 percent “fair share” would be \$520 million—roughly one-third of the amount that California-based organizations have applied for. Applicants are listed at www.ntia.doc.gov/broadbandgrants/applications/search.cfm (viewed on October 12, 2009). The total request in California-based applications was reported in CETF’s “Summary of ARRA Proposals.”

¹⁶ The NTIA grant comes through the State Broadband Data and Development Grant Program, the program authorized by the 2008 Broadband Data Improvement Act and funded with up to \$350 million from ARRA.

¹⁷ California Broadband Task Force, “The State of Connectivity,” 2008. Viewed on October 14, 2008, at www.calink.ca.gov/pdf/CBTF_FINAL_Report.pdf. Governor Schwarzenegger’s official response to the request for comments on the broadband stimulus also notes the importance of economic development: “... without any broadband service, [an area’s] residents are excluded from the economic development and social-economic benefits of broadband, including tele-education, telemedicine, access to health care information, access to government services and benefits, and more.” See California response to BIP/BTOP request for comment, www.recovery.ca.gov/Content/Documents/California_Response_to_NTIA_on_BB_Stimulus_Grants_4-13-09.pdf, p. 12.

¹⁸ CASF chose minimum speeds of 3 megabits per second downstream and 1 megabit per second upstream, arguing that at these speeds telecommuting becomes feasible, and lacking rapid enough connections to work from home qualified an area as “underserved.” See Table 1 and California’s response to BIP/BTOP request for comment, www.recovery.ca.gov/Content/Documents/California_Response_to_NTIA_on_BB_Stimulus_Grants_4-13-09.pdf.

¹⁹ California Air Resources Board, *Climate Change Draft Scoping Plan*, June 2008, page 12.

Broadband Availability and the Digital Divide

California and federal policies seek to close the digital divide in broadband availability, placing a particular emphasis on unserved and underserved areas. ARRA and CASF define unserved and underserved in terms of whether broadband service is available and, if so, at what speed. CETF also mentions “ubiquitous access” and supporting “underserved communities” in its mission statement.

Targeting “unserved” and “underserved” areas requires defining these terms and identifying which areas qualify. Recent improvements in data collection, and planned improvements funded by ARRA, will provide policymakers with much better information on broadband availability. However, for analyzing past trends in broadband availability and the relationship between broadband and local economic development, we must rely on the less detailed data collected historically by the FCC.

Unserved and Underserved Areas

“Unserved” and “underserved,” as defined for the federal stimulus funds, are an important policy statement about what constitutes adequate broadband availability. “Unserved” areas lack broadband service offering downstream speeds of at least 768 kilobits per second (kbps) and upstream speeds of 200 kbps.²⁰ These minimum speeds are lower than typical digital subscriber line (DSL) and cable broadband service today, which often advertise top downstream speeds of 1.5 to 6 megabits per second (mbps) and top upstream speeds of at least 768 kbps (Table 1). “Underserved” areas have either only partial service coverage at those speeds, no service at a higher speed threshold of 3 mbps downstream and 1 mbps upstream, or low adoption rates.²¹

To assess the extent of the digital divide and to help identify unserved and underserved areas, the FCC recently improved its data collection efforts, and ARRA is allocating funds for additional mapping and surveying efforts. Since December 2008, broadband providers have been required to report subscribership levels by Census tract at different speeds of service through the FCC’s “Form 477” data collection process. (Form 477 data is about subscribership, and availability is inferred, based on the location of subscribers. This could result in an undercount of availability in areas where a provider has infrastructure allowing it to provide broadband service, but no subscribers.) As noted above, ARRA also seeks to provide information on unserved and underserved areas. It provides funding for the development of maps showing broadband availability and calls for the development of “a comprehensive nationwide inventory map of existing broadband service capability and availability” by February 2011. Finally, the 2008 Broadband Data Improvement Act requires the FCC to conduct consumer surveys on pricing, speed, adoption, and online behaviors, and to collect international data on broadband speeds and prices.

²⁰ “Downstream” refers to data sent “down” from the Internet to an end-user, such as a downloaded file or a received email. “Upstream” refers to data sent “up” to the Internet from an end-user, such as an uploaded file or a sent email.

²¹ Unserved areas consist of contiguous Census blocks where at least 90 percent of households lack access to terrestrial (i.e., not satellite or mobile phone) broadband service offering speeds of at least 768 kbps downstream and 200 kbps upstream. Underserved areas consist of contiguous Census blocks where either (1) 50 percent of households or fewer have access to terrestrial broadband service of at least 768 kbps downstream and 200 kbps upstream; (2) no broadband service offers speeds of at least 3 mbps downstream and 1 mbps upstream; or (3) 40 percent of households or fewer subscribe to broadband. Note that the standard of 3 mbps downstream / 1 mbps upstream is the level that CASF believes is necessary to support telecommuting, as mentioned in the previous section.

TABLE 1
Broadband speed illustration

| Downstream speed | Relevance | Approximate time to download 3 megabyte pop song |
|----------------------------|---|--|
| 56 kilobits/second (kbps) | Top speed of dial-up modem service | 7 minutes |
| 200 kbps | Minimum speed to qualify as “high-speed” (broadband) under historical FCC definition | 2 minutes |
| 768 kbps | Minimum speed for an area not to be “unserved” according to ARRA | 30 seconds |
| 1.5 megabits/second (mbps) | Lower speed tier advertised for many broadband (DSL or cable) services | 15 seconds |
| 3 mbps | Minimum speed for an area not to be “underserved” according to ARRA, and minimum speed CASF considers necessary for telecommuting | 8 seconds |
| 6 mbps | Upper speed tier advertised for many broadband (DSL or cable) services | 4 seconds |
| 10 mbps | Speed of advanced services available in some areas, including much of metropolitan southern California | 2 seconds |
| 100 mbps | Speed of advanced services available in very limited areas, including parts of metropolitan Sacramento | ¼ second |

NOTE: 1 byte equals 8 bits.

Some states, including California, have already undertaken their own mapping initiatives. Based on infrastructure data collected from providers, California publishes maps of broadband availability throughout the state, disaggregated into several speed tiers.²² Maps dated August 10, 2009, show large rural and mountainous areas in the state without broadband access. The fastest service—more than 100 mbps—is available in parts of the Sacramento metropolitan area; service at speeds of 10–100 mbps is available throughout much of urban southern California, as well as Bakersfield and Napa and Solano Counties; and speeds of 5–10 mbps are offered in most of the Bay Area, including Silicon Valley (Figure 1). These differences demonstrate that even among places with broadband availability, speeds can vary considerably. And much of the state appears to have no service at speeds of at least 500 kbps, thus meeting the definition of unserved or underserved.²³

²² See maps at www.cpuc.ca.gov/PUC/Telco/Information+for+providing+service/Broadband+Availability+Maps.htm.

²³ The speed categories presented in the CPUC map (Figure 1) do not accord with the speeds that define unserved and underserved areas (Table 1), making it difficult to determine which areas qualify for federal stimulus funds based on the map.

FIGURE 1
Broadband Availability in California, August 2009



SOURCE: California Public Utilities Commission, Communications Division, Video Franchising and Broadband Deployment Group.

NOTE: Map used with permission of CPUC.

Limitations of Available Broadband Data

FCC data collected prior to the December 2008 improvements represent the best public historical information on broadband availability, and policymakers and academics have relied on these data to analyze the extent of broadband deployment and the relationship between broadband and economic and social outcomes.²⁴ These historical data consist of the number of subscribers at the state level, disaggregated by advertised speed of service and type of technology (cable, DSL, etc.), as well as a list of ZIP codes where the provider has at least one subscriber to “high-speed Internet service,” defined as at least 200 kbps in at least one direction. Thus, the only sub-state information was the number of providers in a ZIP code with at least one subscriber, which has been published in semiannual reports back to 1999.²⁵

Some caution must be exercised in interpreting these data, because many ZIP codes cover large geographic areas, and providers with a subscriber in a ZIP code might not offer service throughout the entire ZIP code. That said, these ZIP code provider-count data have two strengths for assessing policies designed to raise broadband availability. First, broadband policies are often enabled by adding providers to an area—sometimes directly through public provision and sometimes indirectly through subsidization or regulation; thus, using the number of providers as a proxy for broadband availability is meaningful in a policy context. Second, there is a reliable relationship between the number of providers in a ZIP code and the estimated extent of residential broadband availability, even though the data are imperfect. As explained in the [technical appendix](#), the publicly available FCC data do not distinguish between providers that own the wires and cables that constitute broadband’s infrastructure and those that lease and resell space on these lines to offer service; nor do FCC data indicate how much of the ZIP code each provider serves, nor at what speed. Nevertheless, related research has shown that estimated broadband availability in a ZIP code does increase when the number of providers increases, especially when the ZIP code has fewer providers to begin with.²⁶

What We Know about Broadband Availability

Broadband is widely available. By December 2006, essentially all ZIP Code Tabulation Areas (ZCTAs) in the United States, including those in rural areas, had at least one provider offering service (Table 2).²⁷ This simple metric overstates broadband availability because providers do not always offer service throughout an entire ZIP code. Using an improved methodology that infers availability based on adoption patterns and FCC provider counts, we estimate that broadband was available to 85 percent of U.S. households and 92 percent of California households in December 2005 (Kolko, forthcoming). Looking at the number of providers, broadband availability continued to increase between 1999 and 2006, relative to its level in 1999. The average number of providers per

²⁴ National broadband data collected prior to December 2008 cannot show which areas qualify as unserved or underserved, as defined for ARRA. Historically, the FCC has reported the number of providers in a ZIP code with service at speeds of at least 200 kbps in at least one direction, whereas an area qualifies as unserved if it lacks service of 768 kbps downstream and 200 kbps upstream. Thus, areas with “high-speed access” according to the historical FCC definition could still be unserved or underserved according to definitions for current broadband programs.

²⁵ These semiannual reports and provider count lists are available at www.fcc.gov/wcb/iatd/comp.html. Two reporting changes occurred starting in December 2005: First, providers with fewer than 250 high-speed connections were required to submit data through Form 477, whereas previously they were exempt; second, providers had to start reporting state-level subscribership by technology (GAO, 2009).

²⁶ Kolko (forthcoming) demonstrates the relationship between provider count and availability. This relationship suggests that the logarithm of the number of providers better approximates availability than either a linear measure or an assumption that availability reaches a maximum with one or a few providers. The [appendix](#) of this report discusses other shortcomings with FCC Form 477 data in more detail, as does GAO (2006).

²⁷ ZCTAs are U.S. Census Bureau approximations of U.S. Postal Service ZIP codes. ZCTAs are better suited to data analysis than ZIP codes. See the [appendix](#) for more detail about how ZCTAs and ZIP codes compare and how we converted ZIP code data to ZCTAs. “Rural” means outside a metropolitan area and accounts for roughly 20 percent of the U.S. population.

ZIP code in the nation grew from 3.4 in 1999 to 11.2 in 2006, weighted by employment. The comparable figures for California were slightly higher (5.0) in 1999 and similar (11.5) in 2006.

TABLE 2
Number of broadband providers by ZCTA

| | All areas | | Rural only | |
|---|-----------|------------|------------|------------|
| | U.S. | California | U.S. | California |
| 1999 | | | | |
| Average broadband provider count | 1.6 | 2.9* | 0.8 | 0.9 |
| Average broadband provider count (employment-weighted) | 3.4 | 5.0* | 1.7 | 1.6 |
| Percent of ZCTAs with one or more providers | 63% | 77%* | 42% | 43% |
| Percent of ZCTAs with one or more providers (employment-weighted) | 96% | 98%* | 83% | 81% |
| 2006 | | | | |
| Average broadband provider count | 6.9 | 8.6* | 5.0 | 4.9 |
| Average broadband provider count (employment-weighted) | 11.2 | 11.5 | 8.3 | 7.4* |
| Percent of ZCTAs with one or more providers | 99.6% | 99.93%* | 99.4% | 99.5% |
| Percent of ZCTAs with one or more providers (employment-weighted) | 99.97% | >99.99%* | 99.94% | 99.99% |

NOTES: Asterisks indicate California value is different from rest of U.S. at 5% statistical significance level. "Rural" means not in a metropolitan area. See [technical appendix](#) for further definitions and details.

Since broadband appears, by these data, to be widespread, we may ask why federal and California broadband policy is focused on unserved and underserved areas. The answer is that ARRA, CASF, and other current initiatives use higher speed thresholds than the historical FCC definition of high-speed access (see Table 1). It is very likely that many areas are unserved or underserved relative to these thresholds, even if they have one or more broadband providers according to the historical FCC definition.

Thus, even though historical data on broadband availability do not show which areas qualify as unserved or underserved for the purposes of current broadband initiatives, they do reveal that broadband became available at different times throughout the country. These historical data allow us to identify areas with more and less broadband availability and whether broadband expansion was associated with economic development outcomes.

Why There Is a Digital Divide in Broadband Availability

Why might broadband be more widely available in some places than others? The primary reason is that the costs and benefits of providing broadband depend on local factors. Broadband provision requires fixed costs to extend service to an area: Much of the cost to install or upgrade telecommunications infrastructure is required "up front," regardless of the number of eventual subscribers served by that infrastructure. Thus, in order to spread the fixed costs across more subscribers, providers are more likely to serve areas with high demand for broadband. In addition, infrastructure is more expensive to deploy in some areas, such as those with steep terrain or fewer roads, as broadband lines often follow existing transportation rights-of-way. Finally, broadband availability can vary because most areas in the United States are served by a dominant telephone provider and a dominant cable television provider, and each can make different strategic decisions

about when to introduce broadband service to their regions. State policies about regulating or subsidizing broadband could also affect the level of availability.²⁸

As expected, ZCTAs with higher population density, higher income, and flatter terrain had more broadband providers in 2006, holding other factors constant ([Technical Appendix Table A1](#)). Roughly half of the difference between the number of providers in California and the nation in 1999 (see Table 2) was due to differences in density, income, education, and terrain; the remainder was due to unmeasured factors, which could include state policies or the particular broadband strategies of the telephone and cable companies serving California. By 2006, the gap in availability between California and the United States had closed to a statistically insignificant difference.

The extent and reasons for the digital divide in Internet availability also depend on technology. Compared with today's main broadband technologies, cable and DSL dial-up Internet service involves lower fixed costs and did not lead to persistent geographic disparities in availability. Fiber-to-the-home, which offers speeds much faster than DSL or cable, has high fixed costs of deployment and is therefore likely to lead to a more persistent digital divide than cable and DSL (Kolko, 2007). Even if today's broadband technologies become available everywhere, digital divides in future technologies will probably appear, and "closing the digital divide" will remain a policy goal.

²⁸ We do not attempt to measure the effect of state policies on broadband availability because telecommunications regulations are difficult to quantify in a consistent way across states.

Research Questions and Approach

In this chapter we first discuss the questions this report addresses, explaining the underlying hypotheses and why the questions are important. We then present the empirical strategy that we use in answering these questions. We conclude the chapter with a discussion of other important questions about broadband's effects that lie beyond both the scope of our analysis and the main concerns of current federal and state policy initiatives.

Questions Addressed in This Report

Our analysis answers four questions about broadband expansion and economic growth:

1. Does employment grow faster in areas with greater broadband expansion?
2. Does the relationship between broadband and employment differ by industry or across places? For instance, is it stronger for industries that are more reliant on technology or that use workers who are more technically knowledgeable? Is it stronger in places that are more isolated or that have higher amenities?
3. If there is a positive relationship between broadband expansion and employment growth, does broadband expansion *cause* this growth?
4. If broadband does boost employment growth, who benefits? Is employment growth accompanied by a greater likelihood of employment, higher income, or greater flexibility to be able to work from home?

To answer our first question—whether the availability of broadband is associated with local employment growth—it is helpful to consider why broadband might contribute to this type of local economic development. Obviously, broadband and other information and communications technologies lower the cost of sending and receiving many forms of data, including documents and audio and video content. According to standard economic theory, lowering the cost of one input to a profit-maximizing firm has two possible effects: First, the firm raises its output; second, the firm shifts its mix of inputs toward the input whose cost went down. When the spread of broadband lowers the cost of communication, the net result of these two effects on hiring is theoretically ambiguous. The first effect—raising output—would lead most businesses to hire more labor. But the second effect—shifting toward the inputs that just got cheaper—could cause businesses to use new technology in lieu of labor for some tasks.

Our second question explores how the relationship between broadband and employment varies across industries, types of workers, and places. Again, it is useful to think about why there might be differences. Turning to industries first: Businesses reliant on information technology might increase their employment of workers skilled in using new technology and possibly even reduce their employment of others—shifting, in other words, toward labor that is “complementary” with broadband technology. Broadband would therefore have a larger positive effect on employment in industries whose workers are more skilled in using information technology. Furthermore, even if broadband expansion caused individual firms to reduce employment, economic activity could shift to locations where broadband is more widely available, raising aggregate employment there relative to other areas. Locational shifts in economic activity would be more pronounced in more “footloose” industries—those whose location is not tied to local markets or inputs.

The relationship between broadband expansion and economic growth could also vary across places. Broadband might offer greater benefit for places that are smaller or more isolated, helping local businesses or households to connect with larger markets: This line of thinking lies behind predictions that rural areas might benefit disproportionately from Internet technology. Other examples include areas that have access to a more highly educated labor market (if the more educated workers are better able to use advanced information technologies) and areas with more favorable climates and recreational opportunities (if broadband access allows firms to move further away from suppliers and customers toward locations appealing to employers and workers).²⁹

At the same time, broadband expansion could lead to declines in both employment and economic output in local businesses that begin to face competition from online businesses located elsewhere. For example, broadband expansion might encourage households to purchase goods online instead of in local stores, or to download movies rather than visit their local theaters. As with the other possible links between broadband and local economic activity, the effects will vary by industry: Those businesses most dependent upon local demand, such as retailers or entertainment, are more likely to be hurt by broadband expansion, depending on how easily their customers can switch from local businesses to their online counterparts.

Turning to our third question, it is important to acknowledge that a positive empirical relationship between broadband expansion and economic growth does not, in itself, mean that broadband expansion *causes* economic growth. The reverse might actually be true if broadband providers choose to offer or expand service in areas that are growing faster. Alternatively, population growth could cause both broadband expansion and employment growth. Broadband expansion might follow population growth since more than 60 percent of broadband subscribers are households, according to the most recent FCC broadband report. Once again, this effect could vary by industry: Population growth would lead to employment growth in industries whose customers are local residents. Assessing causality is, of course, essential for predicting whether broadband policies will lead to economic development. Looking at broadband expansion and employment growth in individual industries might help clarify the relationship between broadband expansion and overall employment growth.

Our final question asks who benefits if, indeed, broadband expansion does cause economic growth. The answer depends, in part, on what happens to the population. If population growth accompanies employment growth because people follow jobs, then the likelihood of residents being employed—the employment rate—might not rise much. The effect on average pay and household incomes is unclear as well: Increased labor demand might raise wages, but if labor supply also increases, this would push wages down. Employment growth that raises the employment rate, average pay, or household incomes benefits residents; employment growth that does not might still contribute to property owners' land values or local governments' tax base, benefitting some residents but not others.³⁰

It is quite plausible that targeting unserved and underserved areas for broadband expansion could raise local employment yet offer ambiguous economic returns for residents. Economists are often skeptical about “place-based” policies, which provide geographically targeted infrastructure investments; the broadband

²⁹ “Why Wall Street Is Losing Out To 40 Acres and a Modem,” *New York Times*, December 27, 1998, highlights the relocation of some financial operations to idyllic recreation areas like Jackson Hole and Nantucket.

³⁰ We do not assess the relationship between broadband expansion and property values because the time period we study (1999–2006) coincides with the large and varying house price bubbles in many local housing markets. The geographic variation in price changes during this time is probably too noisy to be a reliable measure of the geographic variation in the capitalization into land values of potential local productivity enhancements such as broadband expansion.

stimulus funds are an example of such policies. According to Louis Winnick (1966), an economist and urban development expert, “Federal programs to change the geography of output are a kind of welfare device to redistribute personal income. But at best it is a clumsy, expensive, and often inequitable device. Not only are the gains to one locality offset by losses to another, but even in the locality of gain the added income frequently goes to the wrong people. ... A disproportionately large share of the increased purchasing power goes to the owners of immobile resources [e.g. property owners] other than labor.”³¹ Furthermore, place-based policies may end up encouraging economic activity in places where that activity might not otherwise be economically sustainable: Many of the places that are unserved and underserved by broadband are so because terrain, remoteness, or low population density raises the cost of broadband provision.³² Yet, in defense of place-based policies, not all people can or want to leave disadvantaged places, and governments are committed to offering basic services to residents in all places.

Research Strategy

The relationship between broadband and economic outcomes at the local level is relevant for assessing policy that targets specific locations for broadband investments. As described above, broadband availability has varied across the nation, and this report takes advantage of these geographic differences to assess how the expansion of local broadband availability relates to changes in many economic outcomes.

Several other studies have also looked at the relationship between broadband and economic development. They have generally found a positive relationship between broadband expansion and employment growth and a mixed relationship between broadband expansion and income (or wage) growth. By using richer data, better measurement, and a wider range of methods, this report offers more definitive answers about the relationship between broadband and economic growth, which are generally consistent with previous work.³³ This report also examines questions left unanswered in previous work, such as causality, the effect on population, and the effect on telecommuting and other forms of home-based work.

Our research strategy consists of comparing changes in several economic outcomes with the extent of broadband expansion. To measure the expansion of broadband availability, we use the FCC’s Form 477 data on the number of broadband providers in a ZIP code, as described in the previous section and the [technical appendix](#). We match these data with economic outcomes from several other data sources:

- The change in employment provided in the National Establishment Time-Series (NETS) database, which reports employment for nearly all businesses in the United States from 1992 to 2006 and includes detailed industry and geographic information. The NETS is based on the Dun & Bradstreet business register.
- The change in employed residents, total and working-age population, average pay, and median household income, all at the county level, from the U.S. Census and other government data sources.
- The change in the likelihood of telecommuting, bringing work home, and operating a home-based business, as reported in surveys conducted by Forrester Research, a technology consultancy. Forrester surveys households annually about technology adoption and related behaviors.

³¹ Ladd (1994), in a review of research on enterprise zones, also notes that the benefits of place-based policies to non-landowning local residents are uncertain.

³² One prominent urban economist (Edward Glaeser) argues that disaster-struck New Orleans (Glaeser, 2005) and economically depressed Buffalo (Glaeser, 2007) should be allowed to shrink, with support given directly to residents rather than to places.

³³ The [appendix](#) offers more detail on related academic and policy research.

The FCC, NETS, and Forrester all report information at the ZIP code level. ZIP code areas are small relative to counties and offer rich detail on local broadband availability and economic outcomes. But official ZIP codes, as defined by the U.S. Postal Service (USPS), change frequently over time and do not accord precisely with county boundaries, Census tracts, or other areas for which data are typically available. Furthermore, while the NETS and Forrester report actual USPS ZIP codes for businesses and households, respectively, the FCC uses its own approximation of ZIP codes. And the Census uses its own ZIP code approximation, the ZCTA (ZIP code tabulation area), for reporting selected demographic and economic measures. We converted data from all these sources to the Census ZCTA definitions to create consistent geographic boundaries across datasets and over time. Most previous research has examined the relationship between broadband and employment growth at larger geographic levels (e.g., counties or states). However, using smaller units of geography is more desirable because broadband availability can vary block-by-block. ZIP codes are the smallest geographic area for which both broadband and employment data are publicly available.³⁴

We focus on broadband expansion and outcomes between 1999 and 2006. Although broadband diffusion began earlier, most growth in the number of providers occurred during this period (the FCC began reporting provider count data in 1999). These years are also most relevant as a guide to what future broadband expansion—through ARRA or other programs—might mean for economic development. The relationship between broadband (or any technology) and economic outcomes might change over the course of the technology’s diffusion.³⁵ Policies designed to bring broadband to still-underserved areas are at the end of the broadband diffusion process (at current broadband speeds, anyway), so more recent experience is a better guide than earlier experience to what might happen in the future.³⁶ To further refine these insights, our analysis highlights the relationship over the period 1999–2006 in ZCTAs with the least broadband provision in 1999. Although data do not yet exist to assess whether the locations that lagged in 1999 are the same locations that remain unserved or underserved by today’s policy definitions, this analysis may offer guidance for the effects of policies targeting today’s unserved and underserved areas.

The first step, then, is to assess the overall relationship between broadband expansion and employment growth. We then look at whether the relationship varies by industry or type of place. Next, we try to assess causality by examining the industry-specific effects and by also using an “instrumental variable” strategy.³⁷ And finally, we examine other outcomes: population growth, changes in the likelihood of being employed, average pay, and household income, as well as the changing prevalence of three types of home-based work: telecommuting, bringing work home occasionally, and operating a home-based business. These additional outcomes reveal how broadband expansion relates to outcomes that households experience.

³⁴ To assess the relationship between broadband expansion and employment growth, the ideal level of geography would be the exact street address because a business can have broadband access only if it is available at its exact location. The ZCTA is the smallest geography for which data are available and is therefore the level of analysis we use for employment growth. In contrast, counties are more appropriate than ZCTAs for examining household labor market outcomes because counties better approximate the size of labor markets and broadband could affect households that are in the same labor market as businesses that adopt broadband.

³⁵ It is ambiguous whether the economic effects, theoretically, might be larger earlier or later in the diffusion process. Early users, by taking advantage of a technology first, might grow to a scale that later users would find difficult to compete with. However, the cost of adopting a new technology can fall over time with technological improvements and knowledge from lessons learned by earlier users, which might increase the economic benefits for later users.

³⁶ Focusing on the 1999–2006 period also allows us to adjust for earlier trends in employment growth, because the NETS data start in 1992. Adjusting for prior trends is important because it accounts for the possibility that earlier employment growth encouraged later broadband expansion, and later employment growth might simply be the continuation of the earlier growth trend rather than the effect of broadband expansion.

³⁷ The instrumental variable strategy identifies a factor – in this case, slope of terrain – that affects broadband expansion without independently affecting employment growth, holding other factors constant. The relationship between employment growth and the variation in broadband expansion that is predicted by slope identifies the causal portion of the effect of broadband on growth, at least for the areas in which slope is a good predictor of broadband expansion. The [appendix](#) offers detail on this approach and the results.

Although our analysis focuses on the 1999–2006 period, there is also some value in looking at the 1992–1999 period, when broadband first became available in some areas.³⁸ The relationship between broadband expansion and economic growth in this earlier period may offer guidance on how policies aimed at hastening the diffusion of early-stage technologies affect local economic development, assuming that next-generation technologies that fundamentally change business processes will have the same relationship to economic activity as did current broadband technology.

Questions This Report Does Not Address

Because federal and state broadband policies are particularly focused on unserved and underserved areas, this report looks at how local broadband expansion relates to local economic outcomes. The methods used in this report and in related research examine the relationship between broadband expansion and local activity *relative to other areas*. Even if broadband had no net effect on employment growth nationally, we could still see a positive relationship between broadband expansion and local employment growth if broadband expansion shifted economic activity from some locations to others, resulting in no net gains in jobs or output. If equity is an important public policy goal, governments could still favor broadband investments that redistribute economic activity toward underserved areas.

Yet broadband policies could also affect economic activity nationally. Numerous countries have set goals not only to close the digital divide by making a minimum broadband service available to all residents, but also to support higher-speed broadband services to keep high-tech industries globally competitive (Li and Losey, 2009). In its own evaluation of broadband deployment in the United States, the FCC considers both the extent and evenness of broadband access among Americans—the digital divide—as well as comparisons with other countries, though there is disagreement about which measures accurately reflect international differences in broadband availability and, accordingly, disagreement about the international ranking of the United States.³⁹ It is thus challenging to estimate the net national benefits of broadband, and attempting to do so requires different methods. Although this subject lies beyond the scope of our report, we do return to the question of national benefits briefly in the conclusion, as measured by consumer willingness to pay for broadband.

Broadband may also offer benefits not fully captured in measures of output, employment, or growth. People use broadband for a wide range of activities, including many—such as sharing pictures with friends or downloading music—that might not fulfill a public policy goal, even though people value these activities. Other benefits—for example, access to news, remote medical services, or distance learning—might be public policy goals but might not be reflected in standard economic indicators such as employment, output, or income. Thus, looking at the relationship between broadband and economic outcomes might exclude some benefits of broadband that do achieve public policy goals and others that do not. Although our analysis in this report focuses on local economic development measures, we also review the limited recent research on other outcomes in our final chapter.

³⁸ As the [appendix](#) explains, a methodological disadvantage of looking at the 1992–1999 period is that we have to assume that no ZIP code had any broadband providers in 1992, so the level of providers that the FCC reported in 1999 equals the change between 1992 and 1999. Another disadvantage of looking at the 1992–1999 period is that we cannot adjust for prior trends in employment because the NETS data start in 1992.

³⁹ FCC 08-88, Fifth Report on broadband deployment, as required by Section 706 of the 1996 Telecommunications Act, June 2008.

Research Findings

Broadband and Local Overall Employment Growth

The overall relationship between broadband expansion and employment growth, as measured by the NETS, is positive. Moving from no broadband providers to 1–3 providers (the FCC groups one, two, and three providers together in its reporting) is associated with employment growth that is higher by 6.4 percentage points over the seven-year period from 1999 to 2006 (Table 3).⁴⁰ The size of this relationship is large relative to the overall national employment growth rate, but employment growth at the ZCTA level shows wide variation, and broadband expansion accounts for relatively little of the variation in growth rates across ZCTAs.⁴¹ The relationship between broadband expansion and employment growth is similar when looking only at areas with few or no broadband providers in 1999. As explained above, these less-well-served ZCTAs in 1999 are the best guide to the relationship between future broadband expansion and employment growth in the areas targeted today by federal and state programs to raise broadband availability. Broadband expansion is associated with a smaller but still statistically significant increase in employment growth of 3.5 percentage points in the 1992–1999 period. (Many of the results discussed in this section are shown in the [technical appendix tables](#).)

TABLE 3
Broadband and economic outcomes, 1999–2006

| | Percentage point change associated with increase in broadband availability |
|---|--|
| Employment growth (ZCTA) | 6.4* |
| Working age population (county) | 2.4* |
| Employed residents / working age population rate (county) | -1.2 |
| Average pay per employee (county) | 1.1 |
| Median household income (county) | -2.4* |

NOTES: Percentage changes reflect the coefficient of the change in the dependent variable, in log form, for a shift from 0 to 1–3 providers or from 1–3 to 4 providers, or equivalent changes in the log of the number of providers. Asterisks denote significance at the 5% level. Employment growth is from the NETS; remaining variables are from Census and BLS. See [technical appendix](#) for detailed explanation and complete results.

⁴⁰ Our regression analysis uses the change in broadband providers in logarithmic form, so adding more providers has a less-than-proportional additional effect on employment and other outcomes. See [appendix](#) for details.

⁴¹ The cumulative national employment growth rate in 1999–2006, according to the NETS, was 0.1 percent, which is well below Census estimates based on business surveys (6.2%) and household surveys (7.5%). The NETS is known to undercount some employment in the most recent years, though local employment growth across counties is highly correlated between the NETS and Census business surveys, especially when looking over multiyear employment changes rather than one-year changes. See Kolko and Neumark (2007) for discussion of the NETS and its comparison to other data sources. The standardized beta of the relationship is .08, meaning that a one standard-deviation increase in broadband availability is associated with a .08 standard deviation increase in employment growth. See [appendix](#) for details.

Broadband and Employment Growth across Industries and Places

The relationship between broadband expansion and employment growth varies across industries. The positive relationship is especially large for utilities; information; finance and insurance; professional, scientific, and technical services; management of companies and enterprises; and administrative and business support services. The relationship in these sectors is much larger than the relationship for overall employment (Table 4) and is positive and statistically significant for all but two sectors: mining and public administration.

TABLE 4
Broadband and industry employment growth, 1999–2006

| Employment growth | Percentage point employment change associated with increase in broadband availability | Highest share of technology inputs | Highest share in computer occupations | Employment location most tied to population |
|---|---|------------------------------------|---------------------------------------|---|
| Management of companies and enterprises (55) | 40.8*** | X | X | |
| Utilities (22) | 16.7*** | | X | |
| Professional, scientific, and technical services (54) | 16.4*** | X | X | |
| Finance and insurance (52) | 14.8*** | | X | |
| Administrative and business support services (56) | 14.1*** | X | | |
| Information (51) | 12.0*** | X | X | |
| Construction (23) | 11.8*** | | | X |
| Agricultural, forestry, fishing, and hunting (11) | 11.6*** | | | |
| Real estate and rental and leasing (53) | 10.2*** | | | X |
| Accommodation and food services (72) | 9.9*** | | | |
| Transportation and warehousing (48-49) | 8.6*** | | | |
| Health care and social assistance (62) | 7.4*** | | | |
| Wholesale trade (42) | 7.1*** | | | |
| Other services (81) | 7.1*** | | | X |
| Mining (21) | 6.6 | | | |
| Retail trade (44-45) | 6.5*** | | | X |
| Manufacturing (31-33) | 6.3** | | | |
| Educational services (61) | 6.1*** | X | | X |
| Arts, entertainment, and recreation (71) | 5.7** | | | |
| Public administration (92) | 0.5 | | | |

NOTES: Numbers in parentheses are the NAICS codes for the industry sector. Industries are ranked by the employment change associated with increased broadband availability. Percentage changes reflect the coefficient of the change in the dependent variable, in log form, for a shift from 0 to 1–3 providers or from 1–3 to 4 providers, or equivalent changes in the log of the number of providers. Asterisks denote significance at the 5% level. Employment growth is from the NETS. See technical appendix for detailed explanation and complete results.

The relationship between broadband and employment tends to be stronger in industries where information technology (IT) services (Internet publishing, telecommunications services, data processing, and related services) represent a larger share of an industry's inputs. These industries include: information; professional, scientific, and technical services; management; administrative services; and educational services. Of these, all but educational services are among the industries whose employment growth shows the strongest relationship with broadband expansion. In addition, industries with a larger share of employees in computer specialist occupations tend to show a stronger relationship between broadband expansion and employment growth. Utilities; information; finance and insurance; professional, scientific, and technical services; and management had a higher share of employees in these occupations, and all five of these industries are among those showing the strongest relationship between broadband expansion and employment growth.⁴² In sum, industries that rely more on technology inputs and on workers in computer specialist occupations—the industries that should benefit more from broadband—are those in which broadband expansion is associated with stronger employment growth.

A possibility raised above is that some businesses could be hurt by broadband expansion if online services compete with traditional businesses. Retail is one example, if people with broadband access choose to shop online instead of at local retailers. Another could be the arts, entertainment, and recreation industry, which could see less local demand for live or on-site events if broadband makes online substitutes available. Both of these industries show weaker relationships between broadband expansion and employment growth, relative to other industries.

The relationship between broadband and employment growth is also stronger in some places than others. For example, the relationship is stronger for ZCTAs with lower population density (and, conversely, weaker for those with higher density)—consistent with the theory that smaller or more isolated areas may benefit more from high-speed connections, giving businesses in these areas access to larger markets. However, even for most high density areas, the relationship between broadband and growth remains positive on balance, just not as large as for lower-density areas. None of the other place characteristics—such as having a more educated workforce, having a better climate, or being a vacation destination—affects the relationship between broadband expansion and employment growth ([Technical Appendix Table A4](#)).

Does Broadband Expansion Cause Employment Growth?

A crucial question for broadband policy is whether broadband expansion *causes* employment growth: If so, then policies to make broadband available should result in local growth. Conceivably, a positive relationship between broadband expansion and employment growth could arise for other reasons. For example, if broadband providers expand in locations where they anticipate future growth, then the positive relationship would in part or entirely reflect this strategic decision of providers rather than a causal effect of broadband on growth. Alternatively, population growth could cause both broadband expansion and employment growth: Broadband providers could invest in areas where population (and therefore demand for broadband) is growing, while at the same time population growth could cause employment growth in industries (such as retail, restaurants, and personal services) that serve local populations.

⁴² The [appendix](#) explains these two industry-level measures of technology intensity. "Inputs" are based on the Bureau of Economic Analysis's input-output tables, which describe the types of inputs—including IT services—each industry uses in producing its output. Occupational data, by industry, are from the Bureau of Labor Statistics.

Our results seem to rule out the idea that broadband providers are explicitly targeting areas where they expect higher economic growth: Later employment growth does not predict earlier broadband growth. The evidence also indicates that population growth is not the main driver. Adjusting the analysis for population growth changes the relationship between broadband expansion and employment growth only minimally: The boost to employment growth falls from 6.4 to 5.0 percentage points but remains statistically significant (Technical Appendix Table A2). Furthermore, the sectors whose employment is most tied to population are not those that show the strongest relationship between broadband expansion and employment growth.⁴³ Jobs tend to locate where people do in industries such as construction, real estate rental and leasing, education, retail trade, and other personal services; these industries are not among those in which employment grows most where broadband expands (see Table 3).

A more technical assessment of causality uses the instrumental variable approach described above, in which slope of terrain in a ZCTA is used as proxy for broadband expansion that should not have any independent relationship with employment growth.⁴⁴ Using this approach, the relationship between broadband expansion and employment growth remains positive and statistically significant, suggesting a causal relationship. However, using this approach, the size of the relationship appears implausibly large and is quite sensitive to how the regression model is specified, which makes us less confident in this result (Technical Appendix Table A5). This approach, therefore, is only modestly suggestive that broadband expansion causes employment growth.

These different approaches, though not definitive, generally point in the direction of a causal relationship and suggest that broadband expansion leads to large increase in local employment growth.

Broadband and Household Outcomes

To assess how the employment growth associated with broadband expansion benefits households, we consider key labor market outcomes. First, we look at the employment rate: the percentage of working-age residents that are employed. Other important outcomes are average pay per employee and median household income, which could change with employment growth because of changes in labor demand, labor supply, or the composition of the workforce.⁴⁵ Finally, we consider whether broadband availability facilitates working from home.

Broadband expansion has no statistically significant relationship with the employment rate. As discussed above, it does not appear that population growth causes both broadband expansion and employment growth. Rather, people may be following jobs: The employment growth associated with broadband expansion could encourage people to move to areas where employment opportunities are expanding. Furthermore, although most people work in their county of residence, some people commute across county lines. In counties where many employees live elsewhere or where many residents work elsewhere, broadband expansion is associated with an increase in employment but not in the number of employed

⁴³ The appendix explains this industry-level measure of whether employment is tied to population, which is based on the similarity between the geographic distribution of employment in an industry and the geographic distribution of population.

⁴⁴ As the appendix explains, the regression includes variables such as road density that, if omitted, could lead slope and employment growth to have a direct relationship and would invalidate this approach.

⁴⁵ The analyses of household outcomes look at the county, rather than the ZCTA, level. Although businesses should be directly affected by broadband expansion only at their exact address, increased demand for employment could benefit workers throughout a labor market, and counties—which are almost always larger than ZCTAs—are a better approximation of labor markets than ZCTAs.

residents. In other words, some new jobs associated with broadband expansion aren't filled by local residents: Employment opportunities attract people who are willing to move or commute.⁴⁶

Broadband expansion is associated with no change in average pay per employee and a decrease in median household income. The results for counties with less broadband availability in 1999—the group which may be most comparable to the places that current broadband policy targets—are similar: There is no relationship between broadband expansion and either the employment rate or average pay per employee. In sum, whatever positive effects broadband may have on employment growth, it did not result in either higher employment rates or higher pay for residents in areas where broadband expanded during the period 1999–2006 period. As described above, these residents may benefit indirectly from employment growth in their county if that growth raises the local tax base or property values, but they do not benefit directly in terms of greater likelihood of being employed or higher earnings or income. Residents who rent, and therefore might have to pay more for housing when property values rise, could possibly become worse off economically from employment growth that raises neither the employment rate nor average pay per employee.

The household outcomes reveal a difference between the earlier and later time periods of broadband's diffusion. In contrast to the later period, broadband expansion from 1992 to 1999 showed positive and statistically significant relationships with average pay per employee, median household income, and the employment rate ([Technical Appendix Table A6](#)). One possible explanation is that businesses that adopted broadband earlier faced a labor market where computer skills were less widespread than in later years; these early adopters might also have had to hire workers with more advanced skills if they had to develop more applications in-house to integrate a nascent and fundamentally new technology into their business processes. Later adopters could rely more on off-the-shelf mass-market applications that workers with more modest technology skills could use.⁴⁷ If the supply of workers with the appropriate technology skills were more limited in the earlier period, that could result in both higher increases in the employment rate and in average pay per employee in areas with greater broadband expansion.

Finally, we examine the link between expanded broadband availability and the likelihood of working at home. At-home work could benefit households by giving them (and their employers, in the case of telecommuting) more flexibility. We find no relationship between broadband expansion and all three types of home-based work: (i) having a formal relationship with an employer to work at home at least one day a week (which the survey refers to explicitly as “telecommuting”); (ii) bringing work home to do outside of normal work hours; and (iii) operating a business from home ([Technical Appendix Table A7](#)). Even for the types of people whose jobs or skills might lend themselves more easily to home-based work—people with college degrees or in managerial or professional occupations—there was no relationship between broadband expansion and changes in doing home-based work.

The absence of a relationship between broadband expansion and home-based work may seem surprising, yet recent experience shows that telecommuting—even in places where technology makes telecommuting possible—is rarer than some have expected. One reason for this might be that communication with remote workers through “telepresence” or other video communications often involves expensive hardware and

⁴⁶ Note that the number of employed residents and the employment rate (reported by the Census) are based on whether residents of a county are employed, regardless of where their employer is located. In contrast, employment growth (reported by the NETS) is based on where businesses are located, regardless of where their employees live. See [appendix](#) for further discussion.

⁴⁷ The NETS data provide information on the number of employees in a business but no information about their education or skill level. Data on the characteristics of workers in firms adopting broadband technology at different stages of broadband diffusion would help assess these conjectural explanations.

much faster broadband connections than the minimum speeds that qualify as “broadband.” Recall that the speed necessary for telecommuting according to the CPUC—3 mbps downstream—is fifteen times faster than what qualifies as broadband in the historical FCC definition. Another plausible explanation is that corporate culture can deter telecommuting, even if all of the requisite technology is available: Telecommuters often feel invisible to their employers, and managers often feel a loss of control and uncertainty about the output of remote workers.⁴⁸ The relationship between broadband and telecommuting could change, however, with the development of low-cost, high-quality video technology and management styles more conducive to remote work.

⁴⁸ “Home Warriors: Telecommuters Need More Than E-mail and a Broadband Connection,” *The Economist*, July 25, 2008. “Top 10 Myths About Mobile Work,” Sun Microsystems Open Work Services Group White Paper, 2008.

Implications and Conclusion

What the Results Mean for Broadband as Local Economic Development Policy

The findings indicate a positive relationship between broadband expansion and employment growth (Table 5). The evidence suggests that broadband may have a causal effect on employment growth: The relationship is strongest in more technology-reliant industries, and population growth does not appear to be the trigger, which was the most plausible alternative explanation to a causal relationship because most broadband subscribers are households, not businesses.

TABLE 5
Summary of findings

| Economic outcome | Relationship with broadband | Possible reason |
|---|-----------------------------|--|
| Employment | Positive and big | Broadband expansion causes existing businesses to expand or redistributes economic activity toward the area |
| Working-age population | Positive | People are mobile and move to where employment opportunities are expanding |
| Employment rate (employed residents / working-age population) | None | Because people are mobile or willing to commute, labor supply grows along with labor demand, and businesses need not pay a large premium for basic technology skills |
| Average pay per employee | None | |
| Median household income | Negative | |
| Telecommuting | None | Home-based work requires faster speeds than the minimum that qualifies as broadband, and many corporate cultures are not well-suited to telecommuting |
| Bringing work home | None | |
| Having home-based business | None | |

NOTE: Employment data are from NETS; population, employed residents, employment rate, average pay, and median household income data are from Census/BLS; telecommuting, bringing work home, and having home-based business data are from Forrester.

However, the large increase in employment growth associated with broadband expansion does not necessarily benefit local residents. Areas with faster broadband expansion between 1999 and 2006 experienced no greater increases in either the employment rate—employment as a share of the working-age population—or in average pay per employee, relative to other areas, and median household income declined. One possible explanation for this is that broadband does indeed lead to employment growth, which encourages people to move or commute to areas where employment opportunities have expanded, and this increase in the local labor supply prevents the increased demand for labor from raising either the employment rate or average pay. Employment growth might still raise local property values and tax bases, but in the absence of more direct benefits for residents, the economic development benefits of broadband are ambiguous. As discussed above, place-based policies—for example, targeted broadband infrastructure investments—often involve uncertain economic benefits for residents.

This debate surrounding place-based policies such as broadband infrastructure investment, along with our finding that broadband expansion raises neither the employment rate nor the average pay of residents, begs the question of whether public money designated for broadband infrastructure might have a larger effect on

economic or social outcomes if the funds were allocated instead toward subsidizing broadband adoption or other needs of disadvantaged households, regardless of where they live. There is no easy answer; but it depends to some extent on the contribution of other potential benefits of broadband, which we discuss below, and how much society values investment in disadvantaged places.

One caution with regard to our findings is that the best publicly available data on broadband's diffusion—the FCC's count of providers in a ZIP code—is an imperfect measure of availability. Although the provider count measure we use in our study is a good proxy for availability and an improvement over previous studies, it does not take broadband speed into account, which can vary considerably across different locations. This limitation may be especially relevant for our finding of no association between broadband expansion and any of three types of home-based work, including telecommuting. While broadband service that meets the minimum speed in FCC's historical definition of broadband may not raise the prevalence of telecommuting, future broadband services that support videoconferencing and other "telepresence" applications might do so. Better broadband data will make the relationship between broadband speed and economic outcomes clearer in future research.

Improving Data for Measuring and Evaluating Broadband

The federal stimulus includes significant funds for broadband mapping and data collection, and the National Broadband Plan has the potential to propose additional forms of broadband research. We recommend two research directions to further the understanding of broadband and its effects. First, we should not only measure the availability, adoption, and use of broadband but also identify potential benefits of broadband and assess whether broadband diffusion is meeting those goals. ARRA is focused on measuring access to broadband but not its effects. Second, although the FCC has already begun to collect better data on broadband availability since December 2008, earlier data on broadband availability—including the data we use in this report—could be much improved with better geographic specificity and information about speeds. To the extent that the FCC or other agencies have collected these data in the past but have not made them publicly available, they should do so. With a better understanding of where exactly and at what speeds broadband became available, researchers can more accurately assess the relationship between broadband and economic development and other outcomes—and offer better guidance to policymakers about how to maximize the benefits of future broadband policies.

Other Possible Benefits of Broadband

Although economic development is a primary goal of ARRA and other initiatives seeking to raise broadband availability, ARRA, in the National Broadband Plan, directs the FCC to consider other possible benefits of broadband, including consumer welfare, health care, education, civic participation, government services, energy independence and efficiency, and public safety.⁴⁹ Very few studies have examined the effect of broadband on these other outcomes.⁵⁰ The most compelling research in these areas either estimates the consumer welfare of broadband based on demonstrated willingness to pay for service or considers how switching from dial-up to broadband Internet access changes online behaviors.

The research on consumer welfare tries to place a dollar value on broadband access, based on what consumers are willing to pay. Yet estimates vary wildly because of different assumptions about how many residents value their home broadband connections well above the \$30–50 per month that many households pay, and how much these people would actually be willing to pay. The estimates of the consumer benefit of broadband range from a few billion dollars per year to hundreds of billions per year, with little way to assess which assumptions about consumer willingness to pay are more accurate.⁵¹ Yet even if it were possible to pin this number down, people might value broadband for activities without any clear public benefit, such as downloading music, rather than for activities often believed to be in the public interest, such as increasing civic participation. To answer the policy question of why government should support broadband, the fact that consumers want broadband is not enough; consumers value many goods and services, such as cars and cable television, which governments do not subsidize. The case for government support of broadband depends on what consumers use broadband for and what effects broadband has.

Recent research shows that people switching from dial-up to broadband spend more time using the Internet but that only some online behaviors change (Kolko, 2009).⁵² Switching to broadband increases the likelihood and intensity of several activities that do not fall under goals promoted by broadband policy: downloading music, purchasing products online, and visiting adult entertainment sites. Among “socially desirable” online activities that do fall under these goals, the only activity that increases is researching health information. There is no change in visits to job or career websites or government websites, including civic participation activities such as getting information about public hearings or contacting elected officials. Changing online behaviors will not necessarily lead to better social outcomes. For example, researching health information online will not necessarily enable people to live longer or healthier lives. But it is difficult to see how broadband will come to affect policy goals such as civic participation without changing online behaviors.

Other research has identified improved health care as a realistic benefit of broadband. One study estimates that broadband will save \$30 billion per year in reduced medical costs and reduced institutionalization due to electronic medical records, remote monitoring of health indicators, and other health applications that depend on broadband (Litan, 2005). Policies have already begun to reflect these possible benefits of

⁴⁹The FCC’s Notice of Inquiry asks whether broadband could contribute to energy independence and efficiency through teleworking, a “smart” electricity grid, or “intelligent” highways that monitor traffic. Fuhr and Pociask (2007) suggest numerous ways that broadband and other information technologies could achieve environmental and energy goals, including better supply-chain management, fewer printed materials, and reductions in driving and business travel.

⁵⁰ Some research has looked at the relationship between Internet access in general and outcomes such as community participation and social ties, racial discrimination in retail transactions, book prices, and other outcomes, but not at broadband specifically. Since dial-up access has long been available throughout the United States, the relevant question for policy is the effect of having broadband access relative to having dial-up access. Studies looking at the effect of Internet access generally do not help us understand the marginal effect of broadband.

⁵¹ See the [appendix](#) for more detail on willingness-to-pay estimates by Crandall, Jackson, and Singer (2003) and Greenstein and McDevitt (2009).

⁵² Other studies, including Anderson (2008) and Hitt and Tambe (2007), also found that broadband adopters increase their time online, but the researchers’ methodology did not allow them to identify effects on specific online activities.

broadband on health. CETF's largest award to date has been to the California Telehealth Network (CTN), connecting clinics, hospitals, and medical centers throughout the state. At the federal level, the FCC's Rural Health Care Pilot Program began in 2007 to allocate over \$400 million for broadband infrastructure and design for health care purposes; this program also supports CTN.

Although we point to health care as a potential area of benefit, the evidence so far is based primarily on online behaviors. Further studies are needed to assess the relationship between broadband availability and social outcomes, even if these effects are too long-term to be immediately measurable: health outcomes could include illness incidence or mortality rates; education outcomes could include attainment of a high school diploma or college degree.

If future studies show evidence of broadband's benefit for health or other social outcomes, broadband policies could consider weighing multiple criteria in determining which geographic areas might benefit the most from closing the digital divide. For instance, policies could explicitly take into account not only which areas have the least broadband availability, but also which areas have the most pressing need for improvements in health care or another outcome that future research discovers is improved by increasing access to broadband.

Broadband: The Next Generation

Federal and state broadband policies seek to invest in broadband in underserved areas to close the digital divide. Yet closing the digital divide is not the only broadband policy that could affect economic development outcomes; and policies that support and hasten early-stage rollout of next-generation technologies, such as extremely fast fiber-to-the-home or new technologies that affect business processes, could have different economic development outcomes than those we report.

What does appear certain is that even if the United States achieves the policy goal of ubiquitous broadband availability at current speeds, and the current broadband digital divide closes, new digital divides will open. Fiber-to-the-home, for example, is likely to promote even more extreme geographic disparity in availability than current broadband because the fixed costs of provision are so high (Kolko, 2007). Recent maps of broadband availability in California already show disparities across the state in available speeds. As average speeds increase, new applications develop that take advantage of—and require—these higher speeds, making what may have been an adequate broadband connection in the past inadequate for applications deemed in the future to be important for participating in the economy or society. Federal and state governments might again consider policies to increase the availability of new technologies in less-well-served areas, expecting specific economic or social benefits from the expansion of the new technology. Our research on recent broadband expansion shows that technologies that contribute to local employment growth might not, in fact, benefit local residents; and we must carefully consider who would ultimately benefit from public investments in next-generation broadband and other new technologies.

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